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When the first European Conference on Applications of Meteorology was launched in Oxford 4 years ago, it was not foreseeable that this conference series would become a firmly established institution. However, the response among the meteorological experts was great and there is more demand than ever today for a separate forum for exchanging information.

The 3rd ECAM will take place from September 23 to 26 in Lindau/Lake Constance and promises to be as lively, interesting and varied as the two before.

The 3rd ECAM is to promote the dialogue between the state and private service providers and the customers and, at the same time, give an overview of the standard of modern meteorology. The mutual exchange of opinions and information, whether on stage during the two round table discussions or in the breaks and at the exhibition stands, will be of great benefit to all participants.

Udo Gärtner
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COST 78 NOWCASTING ACTIVITIES

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INTRODUCTION

COST 78 was established to encourage European cooperation on the development of nowcasting techniques. The number of countries was originally 16 but the COST 78 family has expended and now 18 states have signed the MoU. Progress within the COST Action 78, The Development of Nowcasting Techniques, has been reported at previous ECAM conferences (Liljas,1993, Liljas, 1995). The Action is now in the mid of its final phase and the end seminars will be held in two years at ECAM 99. This paper describes the current activities, some expected achievements and discusses new frameworks for nowcasting business.

CURRENT ACTIVITIES

Phase 1 of the COST Action ended with the edition of "Nowcasting, a survey of current knowledge, technique and practice" (Ref. COST 78, 1996). The second phase started with a workshop in Bologna 1996 (Ref. COST 78, 1997). Three themes were set up for Phase 2. At the workshop projects were identified. Draft project plans were created with objectives, participation, responsibilities, time plan etc. The project groups are relatively small in order to make the management of the projects simple.

Theme 1: Strong convection

I.1 Improvement of techniques for early warning of convection
I.2 Database of Convective Case Studies Using Combined Observations
I.3 Climatology of Convective System
I.4 Identification / classification of storm types
I.5 Nowcasting with observational data and a 1-D convection model

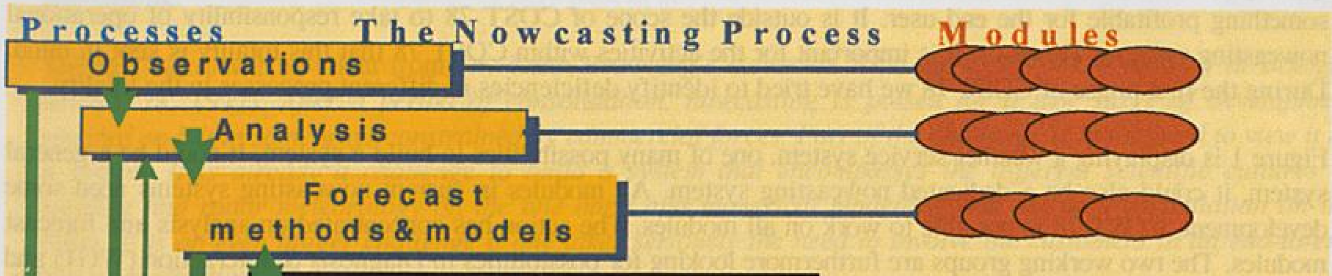

Figure 1. A possible concept of a total nowcasting system. A *total system* consists of several functions or processes starting with the observations and ending with the decision making process of the End User.

Theme 2:	**Fog and low clouds**
II.1	Diagnosis of fog / low clouds
II.2	Improvement of 1-D models for short range forecasting
II.3	Statistical methods and decision support systems for fog and low cloud forecasting

Theme 3:	**Fronts and rapid cyclogenesis.**
III.1	IPV analysis in relation to satellite images
III.2	Refinement of Conceptual Models relating to Fronts and Cyclogenesis

Besides the projects in Phase 2 also 2 Working Groups (WG) have been established.
- WG on tools for graphical interaction
- WG on dissemination of weather information with special emphasis on warnings.

The activities in different parts of Europe are promising. New reports are provided to the Management Committee Meeting just before this Conference and some of the highlights from that meeting will be reported in this presentation but also in other presentations of the same session of ECAM97. The WG on tools for graphical interaction have met at the EGOWS meeting in Toulouse in June 1997. Also some results from this meeting will be reported.

The 2nd COST 78 International Workshop of Nowcasting Techniques will be held in March 1998 in Dresden. The purpose of the workshop will be to monitor the situation in the different projects before the completion of the action. From this the participants will discuss the layout of the COST 78 Final Report. Furthermore the Workshop and the Management Committee (MC) has to discuss if and how the work in COST 78 shall continue, in new COST actions or in other frameworks like EUMETNET, in other EU frameworks and how to involve all COST members in western European activities.(See below.) The Workshop and the MC also must prepare for the final seminar of COST 78.

TOTALITY

The MoU of COST 78 is stating that the nowcasting facilities must be designed as "total systems". Through a quick process the real time information that the weather service has entire disposal of has to be worked up to something profitable for the end user. It is outside the scope of COST 78 to take responsibility of operational nowcasting systems. However, it is important for the activities within COST 78 that this totality is kept in mind. During the first phase of COST 78 we have tried to identify deficiencies in different processes in the totality.

Figure 1 is displaying a weather service system, one of many possibilities to build a system. It could be a general system, it could also be a dedicated nowcasting system. All modules in current nowcasting systems need some development. COST 78 is not able to work on all modules. The action has concentrated on analysis and forecast modules. The two working groups are furthermore looking for possibilities in Diagnosis & Interaction (WG1) and Dissemination (WG2).

COST 78 in relation to EUMETSAT/SAF, EUMETNET, EU 5th FRAMEWRK PROGRAM

There are other important actual and potential cooperation activities in the field of Nowcasting. EUMETSAT has an important role for maintaining and exploiting European meteorological satellites but also for improving the European operational use of satellite data. Therefore the Satellite Application Facility (SAF) for Support to Nowcasting and Very Short Range Forecasting has started a development of products aimed at European nowcasting needs. This R&D activity will result in special modules that will be distributed to EUMETSAT Members to be included in their satellite processing systems, and/or there will be networks in Europe for operational processing of the data from the new instruments, mainly the SEVIRI of Meteosat Second Generation. COST 78 has identified those products and tries to involve those in methodology aiming at modules in a system.

COST is designed for co-operative research, EUMETNET for operational applications. When the objective becomes the development and implementation of operational systems, it becomes worthwhile to consider moving to the EUMETNET framework. The starting point of a EUMETNET programme consists of defining a concrete objective, a time-table and the resources necessary to perform the work. One of the responsibilities of the COST Technical Committee for Meteorology is to identify actions which might lead to operational developments and to organise their transfer to an operational framework. When reporting to the Technical Committee, COST 78 should identify such options when the MC feels that they are mature. Interested parties could then get together and elaborate a proposal with the help of the EUMETNET Co-ordination Office.

There are also good possibilities that research efforts of the EU's 5th FP (the year 1999 to 2001) related to telematics and meteorological issues could be targeted at

- removing lack of standardisation still remaining in weather service processes,
- enhancing the exploitation of public weather data and public-private partnerships,
- increasing the competitiveness and volume of commercial European weather services,
- improving non-commercial services for the "public good", for the increased safety and well-being of all Europeans.

The Telematics Applications are especially important for the involvement of the user community and for the translation of meteorological products into decisions by the weather sensitive users.

CONCLUSION

COST 78 is a catalysis in the nowcasting activities. The activities are high on developing means for improved nowcasting on variables related to strong convection, fog and low clouds as well asfronts and rapid cyclogenesis.

New frameworks are establishing for future nowcasting business. In the completion of COST 78, its MC has to indicate how the started activities shall continue and be transferred into the operational frameworks. Further work on standardisation is needed for future cooperation and avoidance of work duplication and also for a stimulating marketing of components and services. EUMETSAT Nowcasting activities should be incorporated in a total system and framework. EU's 5th FP may provide a positive challenge for European NMSs. EUMETNET is a framework to enhance the European meteorological infrastructure and should/could be a more efficient basis for nowcasting.

The last word will be taken from Dr. Keith Browning's statement from the COST 78 Workshop in Bologna (COST 78, 1977): *After a period of consolidation, nowcasting is poised for a new surge of development spurred on but in some ways constrained by commercial forces. Part of the challenge is in the need to view it as a system. It is already a challenge to build a system that encompasses the different scientific cultures of satellite and radar meteorology on the one hand and numerical modelling and 4D data assimilation on the other. It is an even bigger challenge if one takes seriously the need to involve the customers in an end-to-end system realization.*

REFERENCES

COST 78, 1996: Meteorology - Nowcasting, a survey of current knowledge, techniques and practice, Phase 1 report, Editors: B. J. Conway, L. Gerard, J. Labrousse, E Liljas, S. Senesi, J. Sunde and V. Zwatz-Meise. EUROPEAN COMMISSION EUR 16861.

COST 78, 1997: Improvement of Nowcasting Techniques, International Workshop, Bologna Italy 25-28 March 1996. Editors: B. Conway and J. Labrousse. EUROPEAN COMMISSION EUR 16996

Liljas, E, 1993: Development of Nowcasting Techniques - A New COST Action. First European Conference on Application of Meteorology, 27th September-1st October 1993, Oxford, UK.

Liljas, E,1995: Nowcasting Techniques in Europe and COST 78. Seconde Conférence Européenne sur les Applications de la Météorologie, Toulouse, France, 25-29 September 1995.

NUMERICAL WEATHER PREDICTION AT THE DEUTSCHER WETTERDIENST (DWD)

- CURRENT SYSTEM -

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ABSTRACT

The current operational numerical weather prediction (NWP) system of the DWD consists of a model chain comprising the Global-Modell (GM) for large-scale predictions, the regional-scale Europa-Modell (EM) for the synoptic and meso-α scale, and the high-resolution meso-ß scale Deutschland-Modell (DM) as the main forecasting tool for Germany (Tab. 1). The DM has been developed in close cooperation with the Swiss Meteorological Institute (SMI, Zürich).

The data assimilations GA, EA and DA for the models GM, EM and DM proceed as three parallel streams which are coupled only via the boundary data, namely GM for EM and EM for DM. The analysis of the mass and wind fields is based upon the global ECMWF analysis scheme and has been extended to allow for the analysis of limited domains for EM and DM. The 6-hourly intermittent data assimilation uses 3D multivariate optimal interpolation (OI) for the analysis of the mass and wind field increments. The following observations enter the analysis: SYNOP, SHIP, TEMP, PILOT, SATOB, SATEM, AIREP and ASDAR with an observation time window of 3 hours around the four analyses at 00, 06, 12 and 18 UTC.

The Global-Modell (GM) has been derived from the ECMWF global spectral model (cycle 34) and adapted to local needs. The resolution is T106 (triangular truncation at wavenumber 106) with a Gaussian grid of 320*160 points and a quasi-regular mesh size of ~ 1.125°. In the vertical, 19 layers are used.

The regional model EM covers the North Atlantic and Europe with a mesh size of 55 km in a rotated latitude-longitude grid. Since the task of the model is the production of general weather forecasts for the European area, a proper simulation of near surface processes and the hydrological cycle is of main interest. Therefore about 6 of the 20 model layers are placed in the atmospheric boundary layer.

The high-resolution DM covers central and western Europe with a mesh size of 14 km (Fig. 1) and 30 vertical layers. It allows detailed weather forecasts since it describes the modification of the synoptic-scale flow by the high- resolution topography like the highlands and mountains in Central Europe. Moreover, the DM is able to resolve fronts and convergence lines in great detail. The model results form the basis of quite a number of operational products like meteographs which graphically depict the weather forecast at arbitrary gridpoints or animated clouds and precipitation for TV. The most important use of the DM data is in environmental applications like trajectory calculations, complex dispersion models in case of nuclear or chemical accidents, sea state models, hydrological forecasts or the prediction of road condition.

A workstation version of EM/DM is available to other national meteorological services, universities and research institutions, see Tab. 2 for the current users. Several countries like Brazil, Israel and Rumania started quasi- operational forecasts of EM/DM for their region of interest based on analyses and forecasts out to 84 hours of the GM which are written to the ftp-server of the DWD (ftp.dwd.de) twice daily.

Features of importance when analysing the initiation and life cycle of convective systems that can be obtained either from imagery interpretation or from satellite soundings, include: low-level moisture, middle-level moisture (dry air intrusions), total precipitable water, land surface temperature, thickness advection, low-level winds including sea/lake/river/mountain breezes, upper level winds, cloud thickness, cloud texture, tropospheric stability, cloud top temperature & height, expansion of cloud top, overshooting tops, cloud top phase, storm movement and mesoscale boundaries like dry lines.
Other parameters of importance for convective activity, but difficult to retrieve from satellite data, include: surface pressure (Cacciamani et al., 1995), vorticity advection, low-level and high-level divergence field, environmental helicity (to anticipate the storm type, McNulty, 1995), vertical motion field, strength of capping inversion, height of wet bulb zero (Morgan, 1970, Miller, 1972), position of the jet streak (frontal crossing, Winkler and Zwatz-Meise, 1997). These parametres must be obtained from NWP model data, Synop observations or from mesoscale observation networks. They should be used together with the satellite-derived features to enhance the skill of the short-term forecast.

3. THE SAF FOR SUPPORT TO NOWCASTING AND VERY SHORT RANGE FORECASTING

As part of the Eumetsat Application Ground Segment, in December 1996 a Satellite Application Facility (SAF) in Support to Nowcasting and very short range forecasting has been established, hosted by the Instituto Nacional de Meteorología de España (INM) in co-operation with the National Weather Services of Austria, France and Sweden. The objective of this SAF is the operational extraction of the products listed in tab.2. All products will be available at full SEVIRI resolution for each repeat cycle within 15 min from observation, except the HRVIS winds (25 km resolution, 30 min delivery delay), air mass advection (frequency 30 min) and automatic satellite image interpretation (frequency 3h). The 12 products will allow, together with the original images, the monitoring of most of the above mentioned features of severe weather systems. The products also fit well to the three main projects that have been defined in the COST-78 action of the European Commission, namely strong convection, fog & low clouds, fronts and rapid cyclogenesis (European Commission, 1997). Nevertheless, some features like thickness advection and low level moisture could not be covered by the SAF due to limited sounding capability of the SEVIRI instrument. The applications of the single products are summarised in more detail in tab.2.

No.	Product Name	Characteristics	Retrieval method	Applications of the product	Developer
1	Cloud Mask and Cloud Amount	information on the presence of clouds	succession of threshold tests applied to various combinations of channels for each pixel	the main use of the product is to support surface analysis efforts; in addition, the cloud mask is an essential basis for the generation of other cloud products	Météo France & SMHI
2	Cloud Type (including fog)	major cloud types, fractional clouds, semi-transparancy, fog & stratus identification, snow or sea-ice occurance	succession of threshold tests applied to various combinations of channels for each pixel	the main objective is to support detailed cloud analysis; it may be used as input to an objective mesoscale analysis, which in turn may feed a simple nowcasting scheme, or as a stand alone image product for display at the forecasters desk	Météo France & SMHI
3	Cloud Top Temperature/ Height	vertical extension of clouds, cloud top temperature	for thick clouds: top temperature from thermal window channel accounting for atmospheric attenuation; for semi-transparent clouds: thermal windows histogramm or radiance ratioing method	the main nowcasting application is the analysis and early warning of thunderstorm development; other applications include the height assignment of tropospheric winds derived from cloud tracking, the cloud top height analysis for aviation forecast activities and input to mesoscale models	Météo France & SMHI
4	Precipitating Clouds	identification of clouds likely to produce precipitation within predefined precipitation intensity classes	multispectral threshold technique (algorithms based on AVHRR experience)	the main objective is to support detailed precipitation analysis; especially the identification of intense precipitation and rapidly developing precipitating clouds is important;	SMHI
5	Convective Rainfall Rate	precipitation intensities for convective clouds	regression algorithms or lookup tables using Vis, IR window and WV channels	monitoring of convective systems; there could also be hydrological applications	INM
6	Total Precipitable Water	total amounts of precipitable water in clear areas; cloud water content in cloudy areas	regression algorithms using IR window and WV channels (split window correction)	for the diagnosis and nowcasting of the total available water vapour content in preconvective areas; the product is also useful as input to other satellite-derived products, like surface temperature or atmospheric stability, which need information on atmospheric moisture	INM
7	Layer Precipitable Water	distribution of liquid water and relative humidity per layer	regression algorithms using IR window and WV channels	the product is used to have a rough idea on the vertical and horizontal distribution of moisture in the atmosphere and to detect dry air layers at middle levels (downdraft potential); it may also serve as input to other products like atmospheric stability and air mass advection	INM
8	Stability Analysis Imagery	stability classes in clear air	regression algorithms using mainly WV and 13.4 channels or Neural Networks	information on the stability of the troposphere (latent and potential instability); delineation of unstable and stable areas; experiences with the lifted index derived from GOES soundings have shown that the most powerful use of the product lies in a sequence of images that indicate the tendency towards destabilisation or stabilisation ; other dynamical parameters derived from NWP models have to be overlayd to get a more complete picture of the stability	INM
9	High Resolution Wind Vectors from HRVIS	winds at high resolution (25 km or better) from HRVIS	starting point is technique used for MPEF winds; gradients for target selection; cross correlation for tracking	monitoring of young and mature convective systems and associated cloud structures; analysis and nowcasting of mesoscale wind phenomena and convergence lines	INM
10	Automatic Satellite Image Interpretation	cloud images with text and objective attributes overlays	automatic feature extraction (segmentation of image parts already used for Meteosat images)	quick overview on ongoing physical processes and their effects on cloudiness and precipitation; recognition of possible errors in NWP forecasts; tool for the combination of different data sources; identification of cold fronts, warm fronts, occlusions, wave structure at cold fronts, rapid cyclogenesis, areas of enhanced convection, areas of intensification at cold fronts by jet streak crossing, jet axis, comma clouds	ZAMG
11	Rapid devel-oping Thun-derstorms Product	semiquantitative image product showing features related to the evolution of convective systems	thresholding techniques and expert systems applied to a time-evolution intermediate product	diagnosis and monitoring of convective systems; identification of growing cumulus clouds and determination od areas of notorious cloud top rising; tracking and characterisation of storms; serves also as input to other products like convective rainfall rate and HRVIS winds	INM
12	Air Mass Advection Product	fields with advected air mass parameters; air mass trajectories	advection of air mass parameters with cloud motion vectors or NWP	early recognition of unstable weather situations	ZAMG

Table 2: List of products of the Nowcasting SAF.

Some of the Nowcasting SAF products, like precipitating clouds, stability analysis imagery or air mass advection, are in a very preliminary development stage and it is too early to give information on their expected quality. It is even not guaranteed that these products will have sufficient skill in capturing the physics. Other products, like the cloud products or total precipitable water, are already retrieved successfully in an operational way from Meteosat or NOAA images using well-tested methods. For the cloud products, the NOAA algorithms will therefore be the starting point for the prototyping activities.

4.THE STABILITY ANALYSIS IMAGERY PRODUCT

One of the critical but very important products of the SAF is the stability analysis imagery product. It is planned to derive this product also in the central Meteorological Product Extraction Facility (MPEF) at EUMETSAT, but for the whole SEVIRI processing area on a coarser temporal and spatial resolution (approximately 30 km resolution, hourly).

In order to support the development of this product, a study with the title „use of MSG data to estimate the instability of the troposphere" is currently being performed by the University of Bonn. The first task was the selection of suitable predictors that have a high potential to estimate the development of severe weather events and are retrievable from the SEVIRI observations with a sufficient accuracy. The following parameters have been identified for the estimation of latent instability: the K-Index (George, 1960), the Lifted Index (Galway, 1956), the equivalent potential temperature at middle layers and CAPE (Moncrieff and Miller, 1976). Both types of CAPE, the one calculated from a parcel lifted from low-level maximum of θ_e (lifted CAPE), and the one calculated from diabatically heated surface parcels (heated CAPE) are considered. For the estimation of potential instability the KO-index (used by DWD), the Bradbury Potential Index (Bradbury, 1977), low-level precipitable water and low-level θ_e were included. Other well known indices like the Showalter Index and the Negative Buoyant Energy Index are also considered for comparison reasons.

No	Date	Max convection (UTC)	Region of interest	Remarks
1	4-7-94	12:00	W. Germany	local air mass storms (Cologne hail-storm)
2	16-7-94	16:00	Estland	
3	2-8-94	15:00	Sicily	Mesoscalw Convective System
4	2-9-94	18:00	Tunisia	
5	4-9-94	9:00	Ibiza	Mesoscale Convective System
6	14-9-94	21:00	W. Mediter-ranean	Mesoscale Convective Systems (complicated case due to extended frontal clouds)
7	4-11-94	14:00	Italy	pre-frontal supercell storms in a strong southerly upper level flow (150 mm/6 h, beginning of Piedmont flood)
8	15-7-95	15:00	E. Europe	
9	25-7-95	2:00	Atlantic	
10	2-8-95	20:00	Atlantic	
11	3-8-95	13:00	Norway	
12	24-8-95	10:00	Sweden	
13	19-9-95	16:00	Italy, Slovenia	Friuly flash flood; difficult case due to low-level Sc clouds; storms triggered by surface convergence
14	6-11-95	18:00	Atlantic	cut-off low SW of Europe; explosive development of storms from a small cloudy zone
15	24-11-95	15:00	Tunisia	
16	29-3-96	20:00	Spain	difficult case due to extended cloudiness
17	8-5-96	16:00	Austria	numerous thunderstorms in a warm air mass, far ahead of a weak cold front over NW Europe
18	25-5-96	17:00	Austria	scattered thunderstorms along a cold front over Central Europe, but also ahead of it (pre-frontal storms)
19	30-5-96	not appl.	France	very stable high pressure situation over Central Europe and Mediterranean
20	12-6-96	17:00	Alps	widely scattered frontal thunderstorms along a weak front during a very hot period (34-36°C over threat area)
21	19-6-96	12:00	Toscana	very intense pre-frontal storms after a very hot period with approaching upper level trough (more than 476 mm/6 h)
22	22-6-96	0:00	N. Italy	pre-frontal and frontal storms enhanced by orographic blocking; difficult situation due to extended cloudiness (mostly Sc)
23	4-7-96	12:00	W. Germany	
24	15-7-96	not appl.	Benelux	high pressure over Central and Western Europe; only isolated thunderstorms in the Alps late in the evening (23.00 UTC)
25	23-7-96	12:00	Benelux	extremely unstable air at and in the rear of a cold front crossing Central Europe; formation of a line storm

Table 3: List of test cases.

The next task was to simulate SEVIRI radiances for 25 carefully selected test cases from NWP model data using a RTM called STREAMER (author Jeffrey R. Key, Boston University, 105 bands in the thermal infrared from 4.03 to 500 µm). Two models are used for this task, namely the „Europamodell" (EM, 50-55 km resolution) and the experimental „Lokales Modell" (LM, 2.8 km resolution). A huge amount of computation time is needed for this task considering that the simulation of 140x140 gridpoints of the LM takes about three days. The test cases cover a wide range of severe weather situations in different seasons/reagions in Europe and the Eastern Atlantic (see tab.3). The simulated radiances are converted into brightness temperatures and then fed into a Neural Network to retrieve the instability indices.

The retrieved indices are then compared to indices calculated from the model data, for both the data set that had been used to train the Neural Network (self test) and an indipendent test case data set (test). Some preliminary results obtained from the simulations with the Europamodell for test case no.24 are shown in fig.1 for the Surface K-Index (SK-Index). When including all points (including those contaminated by clouds), the satellite-derived SK-Index has a large negative bias compared to the model-derived index and correlation is low, especially for small values of the SK-Index. Excluding cloudy points from the algorithm leads to a significant improvement. The scattering of the points is still quite large for low SK-Index values, but promising small for high values of the SK-Index. It has to be tested whether all cloud contaminated points have to be excluded, or if low-level clouds can be kept in the algorithm. This is very important, since severe storms frequently develop in areas of low Stratocumulus clouds.

The next step of the study will be to look at the spatial structure of the simulated indices and at their time evolution, and to demonstrate the performance using actual satellite data from the NOAA AVHRR and/or TOVS. The experience with the Lifted Index derived from the GOES sounder (18 channels) gives rise to the expectation that every one image will be quite noisy and uncertain, but having a loop will probably enhance the quality of the product and help forecasters in detecting areas where strong convection is likely to occur. It is currently tested whether the splitting between night and day cases or the splitting into different geographic areas will help to improve the results. Night-time storms, which are very frequent in the Mediterranean area, are based on a different physical mechanism than day-time storms, i.e. the lifting that is neccessary for initiating the convective process must not necessarily start from close to the surface, but may originate above the boundary layer (elevated thunderstorms, Colman, 1990a,b). The regional splitting will probably also be necessary in order to account for the north-south gradient in temperature and moisture.

Finally, the possibilty of retrieving an instability product on a global scale at a coarser resolution will be assessed. Probably some information will be lost, because convective systems are mostly initialised on small spatial scales. Another possible effect will be that the ranges, and consequently also the thresholds, for the predictors will change.

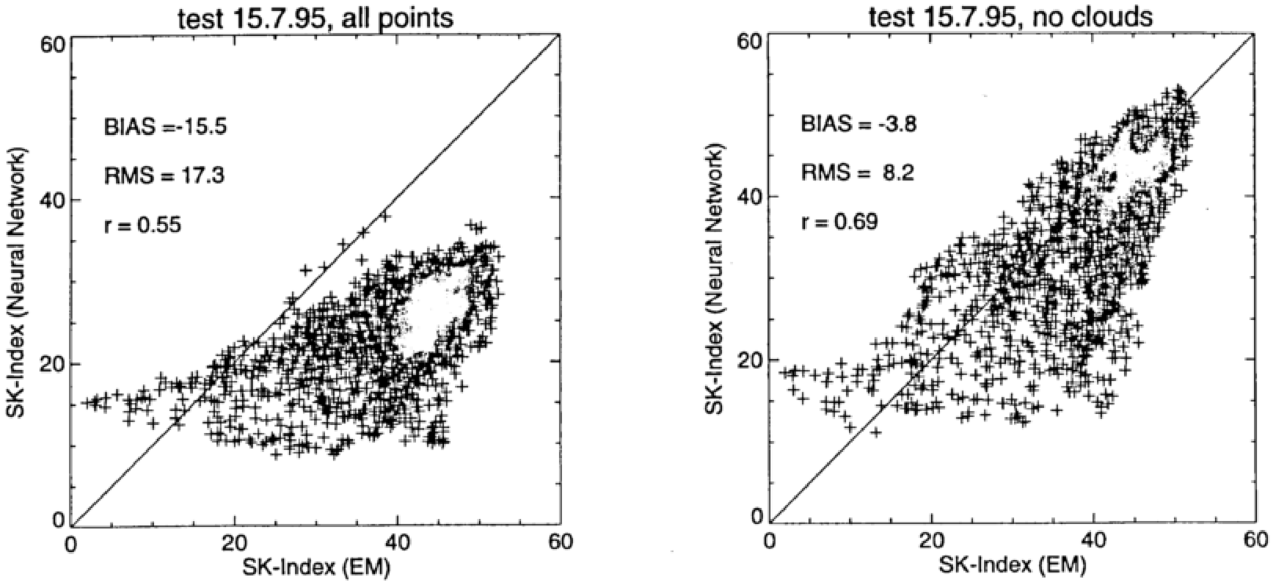

Fig.1: Scatterplot of model-derived Surface K-Index (EM) against the same index derived from simulated SEVIRI brightness temperatures using a Neural Network (Neural Network). The Neural Network had been trained with data from test case 25 (see tab.3). Left side: all points, including cloud contaminated points, are used in the Neural Network. Right side: cloudy points are excluded.

5. CONCLUSIONS

The 12 products derived from the second generation Meteosat satellite series in the context of the SAF in support to nowcasting and very short range forecasting will provide a powerful tool for the nowcasting/forecasting of strong convection, fog & low clouds, fronts and rapid cyclogenesis. The final deliverable of the SAF will be a portable software package to be run locally at the national and regional forecasting centres of the EUMETSAT member states. After a preparatory phase of 12 months, the development of the software will start early 1998 using data from NOAA and GOES satellites and simulated SEVIRI data. The final integration and validation will be done in the years 2000 and 2001 when the first real data from SEVIRI will be available. In order to assure that the development is going in the right direction (interesting products for the user comunity, easy utilisation), co-operation with the future user comunity is required during all 5 years of the development. It is the intention of this paper to stimulate this co-operation and to present the Nowcasting SAF activities to a wider group of users.

BIOBLIOGRAPHY

Bradbury, T.A.M., 1977: The use of wet-bulb potential temperature charts. Meteor. Magazine, **106**, 233-251.

Cacciamani, C., Battaglia, F., Patruno, P., Selvini, A. and S. Tibaldi, 1995: A climatological study of thunderstorm activity in the Po Valley. Theor. Appl. Climatol., **50**, 185-203.

Colman, B.R., 1990a: Thunderstorms above frontal surfaces in environments without positive CAPE. Part I: a climatology. Mon. Wea. Rev., **118**, 1103-1121.

Colman, B.R., 1990b: Thunderstorms above frontal surfaces in environments without positive CAPE. Part II: organization and instability mechanisms. Mon. Wea. Rev., **118**, 1123-1144.

European Commission, 1997: COST 78: improvement of nowcasting techniques. International workshop held in Bologna, Italy, 25-28 March 1996, EUR 16996 EN, 225 pp

Galway, J.G., 1956: The lifted index as a predictor of latent instability. Bull. Amer. Meteor. Soc., **37**, 528-529.

George, J.J., 1960: Weather forecasting for Aeronautics. Academic Press, New York, pp 409-415.

McNulty, R.P., 1995: Severe and convective weather: a central region forecasting challange. Weather and Forecasting, **10**, 187-202.

Miller, R.C., 1972: Notes on analysis and severe-storm forecasting procedures of the Air Force Global Weather Central. Air Weather Service, US Air Force, Technical Report 200 (Rev).

Moncrieff, M.W. and M.J. Miller, 1976: The dynamics and simulation of tropical cumulonimbus and squall lines. Quart. J. Roy. Meteor. Soc., **102**, 373-394.

Morgan, G.M.Jr., 1970: Hailstorm studies at the observatory of the Institute for Atmospheric Physics, Verona, 1969. Istituto di Fisica dell´Atmosfera (IFA), TR Nr. 31, Roma.

Winkler, R. and V. Zwatz-Meise, 1997: Manual of Synoptic Satellite Meteorology: Conceptual models. ZAMG publication, Wien.

PRODUCTION OF NOWCASTING WARNINGS BASED ON THE FORECAST PRODUCT EDITOR OF THE METEOROLOGICAL WORKSTATION PROJECT (METAP)

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ABSTRACT

The process of issuing warnings basically consists of an observational phase and a production phase. In the observational phase the forecaster monitors the meteorological evolution and specific meteorological parameters (e.g. windspeed). In the production phase the forecaster issues a warning for a specific customer.

In the Swiss Meteorological Workstation Project (metAP) a forecast product editor is realized. This tool allows the efficient production of forecast products and warnings. Warnings are issued for predefined geographic regions, thus the selection of the specific template of the warning document or message is via a map of Switzerland. The product is edited, sent off and converted to the customer format(s). The dissemination of the warning to the customer ends the process within the SMA-*MeteoSchweiz*.

INTRODUCTION

The Swiss Meteorological Workstation Project (or metAP for "meteorologischer Arbeitsplatz") is a long term project of the SMA-*MeteoSchweiz*. The main goals of the metAP-project are a fast and easy visualization of weather data, the realization of an efficient tool for forecast production (the Forecast Product Editor FPE) and the integration of nowcasting methods.

In the realm of nowcasting strong winds, and the production of warnings therefrom, a two step process is followed. As an ongoing task, the forecaster in charge observes and monitors significant weather parameters. Depending on his or her interpretation of the possible evolution the forecaster may decide to issue a caution message or a warning. The observation and warning tasks lead to the following requirements for a production system in the nowcasting time range:

- Possibility to monitor specific meteorological parameters
- Fast selection of a region for the warning
- Use of templates and easy completion of the warning product
- Reliable and flexible dissemination of warning product
- Product deliverable in different document formats (TELEX, FAX etc.)

The observation/monitoring and nowcasting/production tasks are separated in the work process and in the software implementation. The observation and monitoring mainly is done with tools like the "wind-alarm monitor", the "SRN-display" (display of weather radar data) and the quasi-geographic display of 10 minute data of the Swiss automatic measuring network. The following paragraphs focus on the warning selection, production and dissemination.

NOWCASTING APPLICATION CONCEPT

The metAP software is the production application running on the workstation of the forecaster in charge of warnings. Figure 1. shows a "information" flow diagram for the production process.

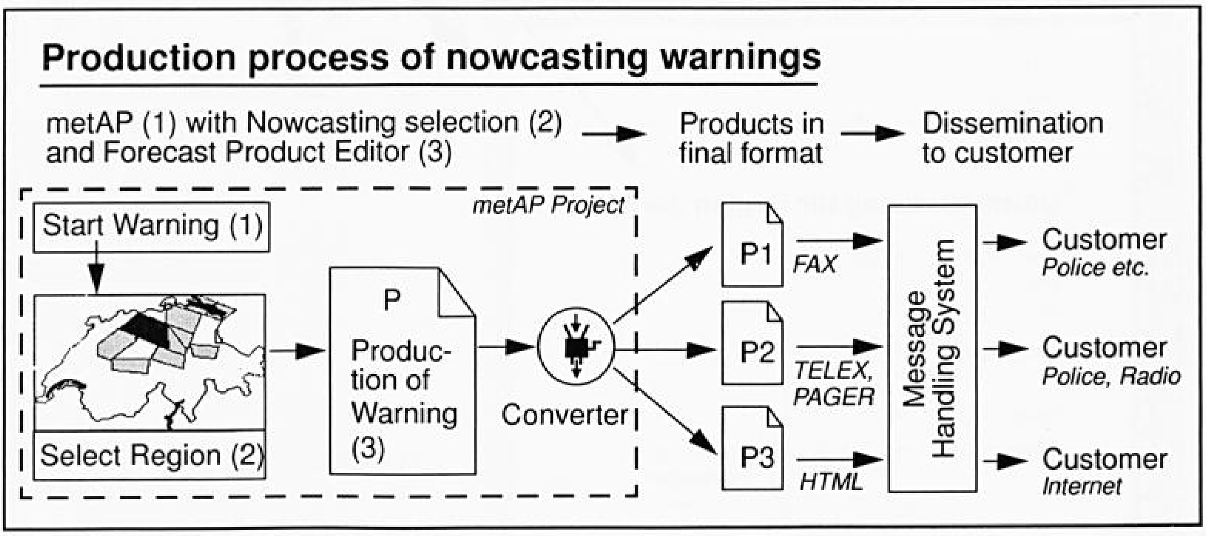

Figure 1. Nowcasting production process.

The metAP-software (see Pauli et al. 1995 for the user interface concept) consists of a central control window, a special region based selection window and the forecast product editor (FPE). The converter also is part of the metAP, but has no graphical user interface. The converter brings products (P) into the end user formats (e.g. FAX (P1), TELEX/PAGER (P2), HTML (P3)). The products finally are delivered to the customer(s) by means of a message handling system.

Note that a warning has to be done once and then can be delivered many times. The numbering in Fig. 1 shows the three steps the forecaster needs to do in order to warn a customer of an extreme meteorological event.

PRODUCTION OF NOWCASTING WARNINGS WITH THE FPE

The nowcasting warning application is started from the metAP control window ((1) in Fig. 1) and the selection window is displayed ((2) in Fig. 1). The selection window as shown in Figure 2 contains a map of Switzerland with the outlines of the predefined warning regions for the corresponding warning type (e.g. wind, frost). Moving the cursor over such a region highlights the area. After the selection of a region (each region has to be done separately) the Forecast Product Editor starts up and provides the forecaster in charge with a predefined template for the region specific warning product (Fig. 2). The forecaster does the final editing (e.g. type of warning, direction of wind, wind burst maximum) and quality checks the warning product. The product can then be disseminated.

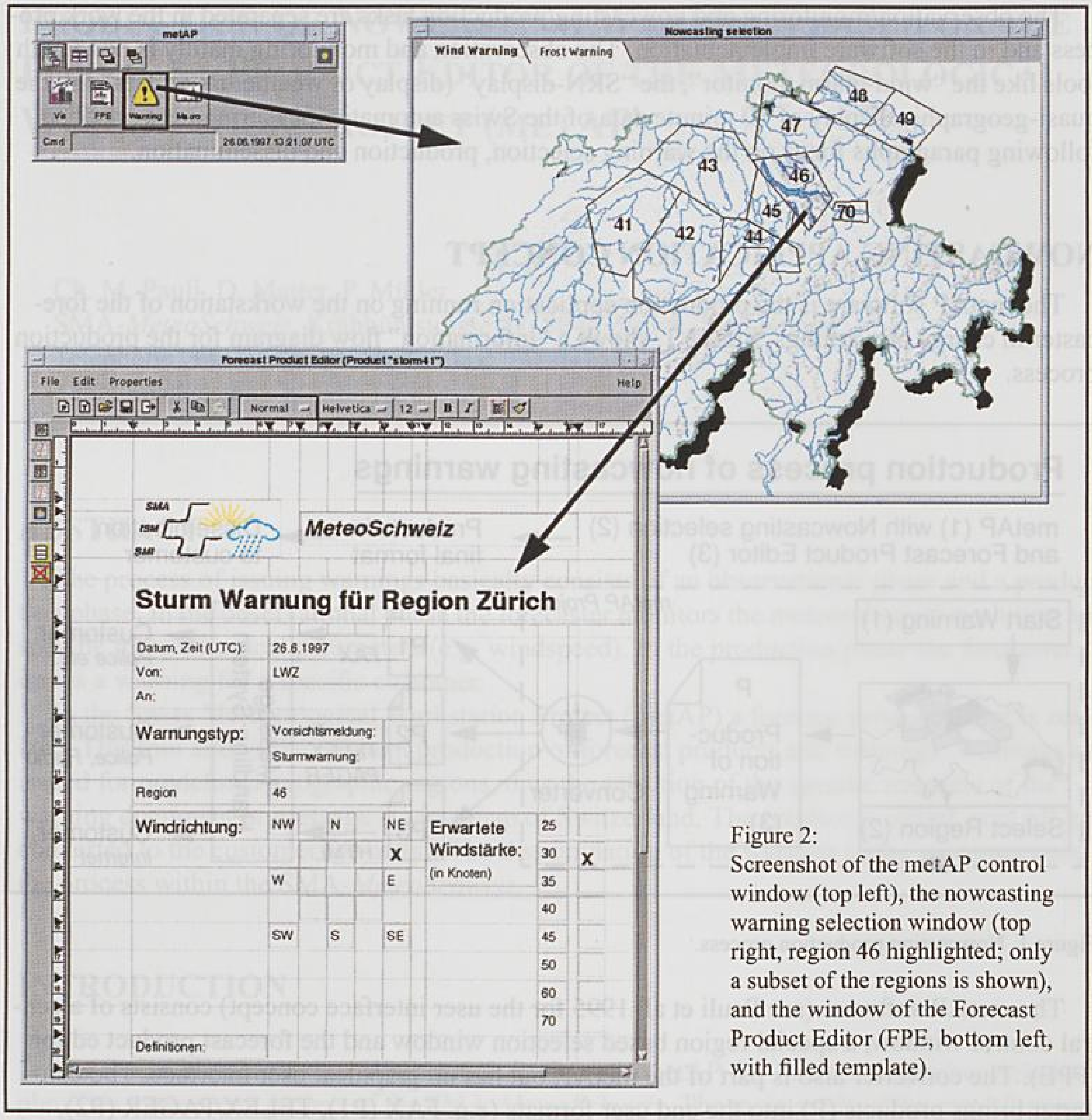

Figure 2:
Screenshot of the metAP control window (top left), the nowcasting warning selection window (top right, region 46 highlighted; only a subset of the regions is shown), and the window of the Forecast Product Editor (FPE, bottom left, with filled template).

CONCLUSION AND OUTLOOK

The nowcasting warning production process as outlined here allows the fast selection of a region for the warning, uses templates to minimize the editorial work by the forecaster and allows the dissemination of the warnings in different formats for various customers. The process is efficient. The system as described in this article currently is near the end of the realization phase. Additions such as a visual clues e.g. for warnings that were issued earlier are planned. First pre-operational tests by the forecasters started.

LITERATURE

Pauli, C., Matter, D. & Ambrosetti, P. 1995. "Swiss Meteorological Workstation Project". Proceedings of the "Fifth Workshop on Meteorological Operational Systems". ECMWF Reading, UK.

USE OF LIGHTNING DATA FOR NOWCASTING OF SEVERE STORM PROPAGATION

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ABSTRACT

Strong convection with the associated hail, gusts, and flooding is one of the major causes of weather related damages in central Europe. Lightning is a natural indicator of thunderstorms, marking the most intense cells of convective storm systems. High lightning activity in convective clouds is strongly correlated to hail and heavy precipitation. A statistical analysis (Finke and Hauf 1996a) reveals that storms moving over more than 200 km are observed on nearly the half of all thunderstorm days. Since lightning data is available in real time, it can be used for nowcasting purposes.
We present a tracking algorithm basing on lightning information for the nowcasting of storm propagation and evolution. The lightning data were provided by the Bayernwerk AG, which operates a Lightning Position and Tracking System (LPATS) covering the range of Southern Germany. For a description of the system and a climatology of lightning distribution see Finke and Hauf (1996b).

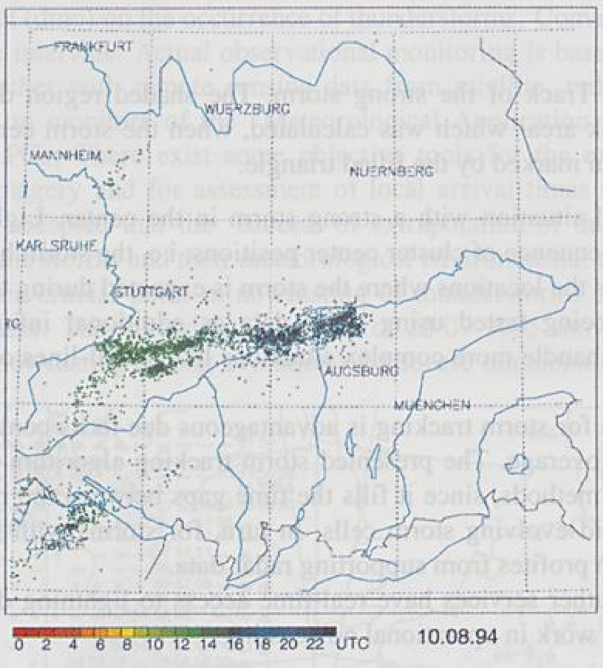

Figure 1: Lightning positions for the time interval 1400-1700 UTC.

The algorithm performs every 4 minutes an analysis to define cluster of lightning positions using the data of the most recent 15 minutes. Hence, the time intervals overlap to a large degree. This enables to link the clusters found in the subsequent time steps into storm tracks. Every new cluster is assigned to an existing storm track if the number of common lightning events is maximal. Clusters with no precedors are 'new born' storms, while existing storms which could not be assigned to any new cluster are considered as 'died'. Each cluster is characterized by center position, lightning number, and geometrical size parameters. A storm track is characterized by the time series of these parameters. The cluster propagation speed and direction is calculated and its future position is estimated by linear extrapolation. Basing on the actual size of the region with high lightning density and the propagation speed a 'storm risk area' for the next 30 minutes is defined.

Figure 2: Track of the strong storm. The shaded region denotes the 'storm risk area' which was calculated, when the storm center was at the postion marked by the filled triangle.

Figure 1 shows a typical situation with a strong storm in the center. Lightning flash positions are displayed by color. The sequence of cluster center positions, i.e. the storm history is displayed on Fig. 2. The shaded area covers the locations where the storm is expected during the next 30 minutes.
The algorithm is now being tested using radar data as additional information. It needs further improvement in order to handle more complex situations like squall-lines or splitting and merging of storm cells.
The use of lightning data for storm tracking is advantageous due to its continuous sampling and high homogeneity in spatial coverage. The presented storm tracking algorithm is an ideal supplement to the radar-based tracking methods, since it fills the time gaps between the radar scans and supports a better recognition of rapid evolving storm cells. In turn, for storms with low electrical activity the lightning based algorithm profites from supporting radar data.
Since many national weather services have real-time access to lightning data the lightning tracking algorithm is suggested to work in operational nowcasting.

References:

Finke, U., T. Hauf, 1996a: The Characteristics of Lightning Occurence in Southern Germany. *Contr. Atmos. Phys.*, 69, pp. 361-374.

Finke, U., T. Hauf, 1996b: An Observational Study on Propagation and Lifetime of Convective Storms in Central Europe Based on Lightning Data. *Seventh Conference on Mesoscale Processes*, September 9-13, 1996, Reading, United Kingdom, pp. 611-612.

Performance Capacity and Limits of Operational Short-Term-Forecasts in Summer Thunderstorm Situations

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ABSTRACT

In the domain of very short range weather forecasting the situation has improved in the last years considerably. Advanced remote sensing systems now provide a lot of real time information about the actual weather situation. Though small scale weather systems responsible for the development of the local weather in the next hours cannot be directly described by numerical weather prediction models, the forecaster is supported to a large extent by mesoscale or local numerical output. New developments in prediction for the next hours are aiming at more automated procedures. This can be seen for instance within the scope of the European nowcasting project "COST 78".

The Deutscher Wetterdienst (DWD) is like other operational weather forecasting services in a transitional stage characterized by use of advanced numerical output and broad remote sensing information, but producing nowcasts in a mixture of subjective and objective methods. For early warning of thunderstorm situations the forecaster in the DWD can make use of basic numerical output from the "Europa-Modell" (EM), specialized deep convection field forecasts (type and vertical extent of convection, 2h precipitation amounts) from the mesoscale "Deutschland Modell" (DM) and local direct model output (dmo) on the occurrence of thunderstorms. Convection fields of the DM are resolved in 1 hour time intervals. Actual observational monitoring is based on conventional surface and upper air data together with remote sensing data from satellite, radar and lightning location, displayed in real time on monitors of the "Meteorological Application and Presentation System" (MAP) and of special PCs. There exist some objective tools for the extrapolation of convective structures in satellite imagery and for assessment of local arrival times of storm clusters in radar images. It is generally accepted that the success of extrapolation of thunderstorms is basically a problem of the scale of the storms and their meteorological environmental conditions. One of the best ways to demonstrate this crucial point in nowcasting of thunderstorms are case studies of typical thunderstorm development. The following case study of 22-07-1995 shows typical problems which are met in operational nowcasting during evolution of a severe thunderstorm situation.

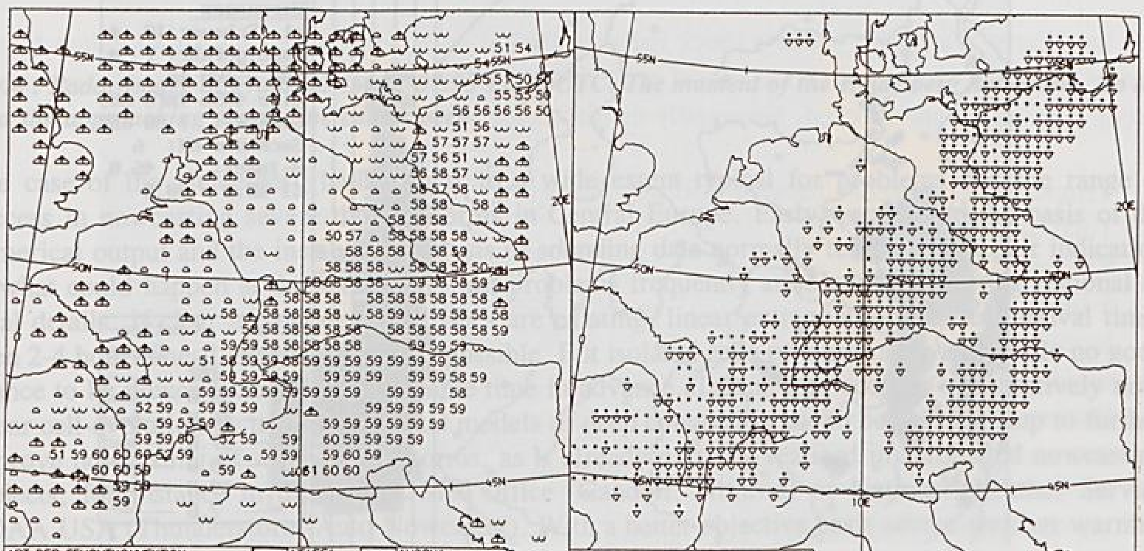

Fig.1: 12h DM-Forecast for 22-07-95 12 UTC. Left vertical extent of convection, right typ of precipitation

In the morning of 22-07-1995 field and local numerical output of EM and DM models made clear indications of an intensifying cold front approaching from the NW. In advance of it wide spread deep convection was expected by the DM in subtropic air to develop by noon with top temperatures of -58°C to -59°C all over southwestern and southern Germany **(Fig.1)**. Also the local numerical products where showing thunderstorm development for that day. The instability analysis of upstream and German upper air soundings confirmed a probability of severe thunderstorms. Therefore the forecasters issued general advices and warnings for storm development. After 06 UTC rapid isolated convective cell development became apparent in satellite images over the eastern half of France, heading to Germany. In radar images of Frankfurt/M a strong, clear-cut, and relatively narrow, short squall line in form of a bow echo spread out from 09 UTC beyond the borderline of France and Germany **(Fig.2)**.

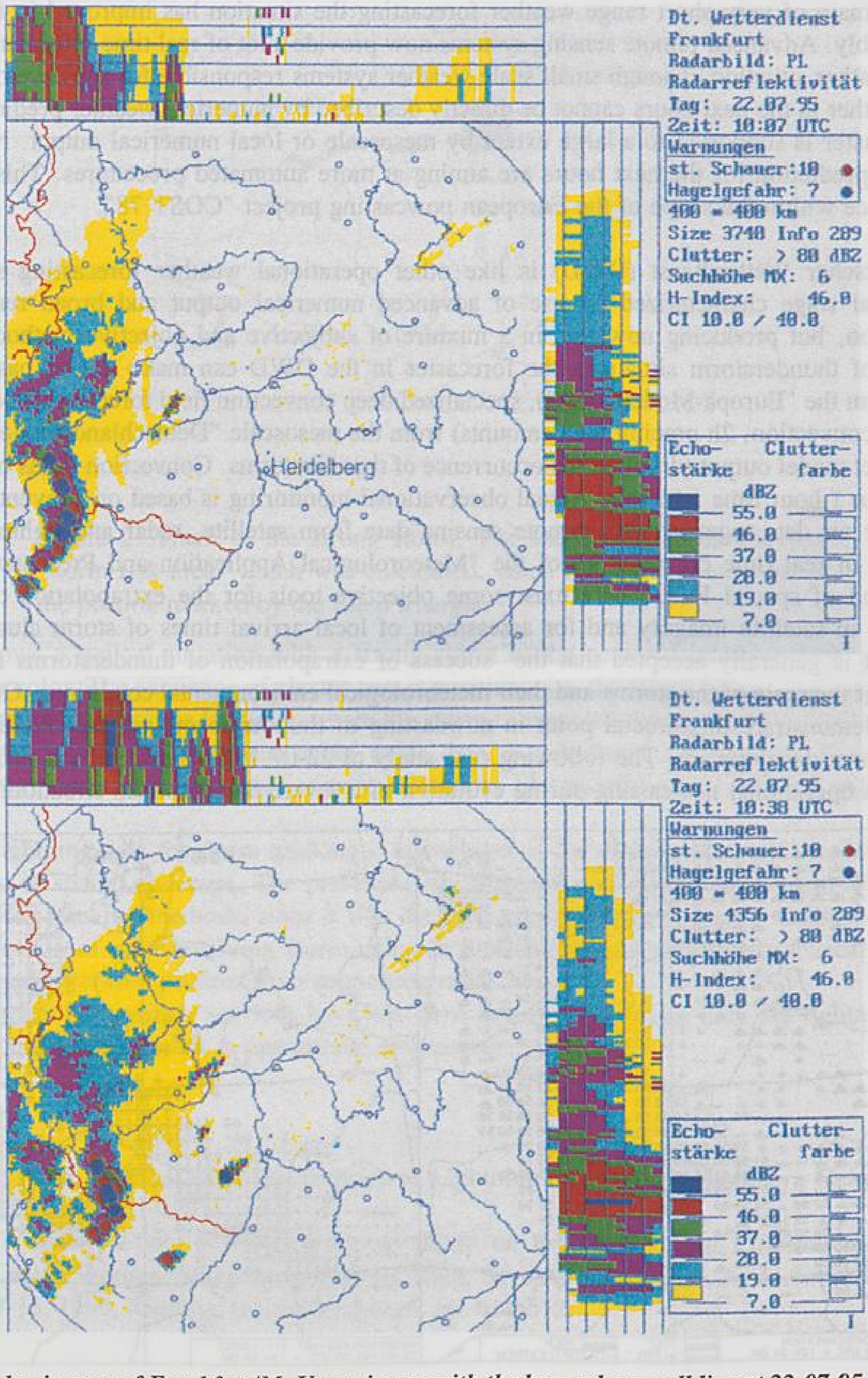

Fig.2+3:* *Radar-images of Frankfurt/M. Upper image with the bow-echo squall line at 22-07-95 10:07 UTC and the location of Heidelberg. Lower image showing new rapid development at 10:38 UTC southwest of Heidelberg.

Compared with the numerical forecast the position of the convective activity was retarded and much smaller in extent, but with the forecasted degree of severeness. The high reflectivity values and the vertical structure of the cells along the squall line together with hail warning markers were indicative of distinct hail risk and severe weather. The well-defined mesoscale structure of the squall line appeared to be favourable for a linear extrapolation on the way to the east. Using the hail markers of a time interval of 1/2 h a forecast of the arrival time in the Rhein valley could be made. For the city of Heidelberg, about 150 km in front of the squall line, the estimation resulted in an arrival time of 12.30 UTC, with an extrapolation of 2 1/2 hours . Surprisingly, half an hour later, after 10.30 UTC only 45 km southwest of Heidelberg at the western edge of the Rhein valley a new isolated multicell system was exploding **(Fig.3)**. Of course this required a new assessment of the arrival time for Heidelberg. With linear extrapolation this new arrival time was made for 11.30 UTC to 11.45 UTC, leaving a reaction time of only 1 hour. This last nowcast proved to be a rather exact one. After 11.30 UTC a severe hailstorm with flash flooding occurred in Heidelberg ***(Fig.4)***. After draw off of the severe storm the squall line, which was continuing to move eastward, arrived at Heidelberg past 12.30 UTC, hence being in good agreement with the first estimation 2 1/2 hours ago.

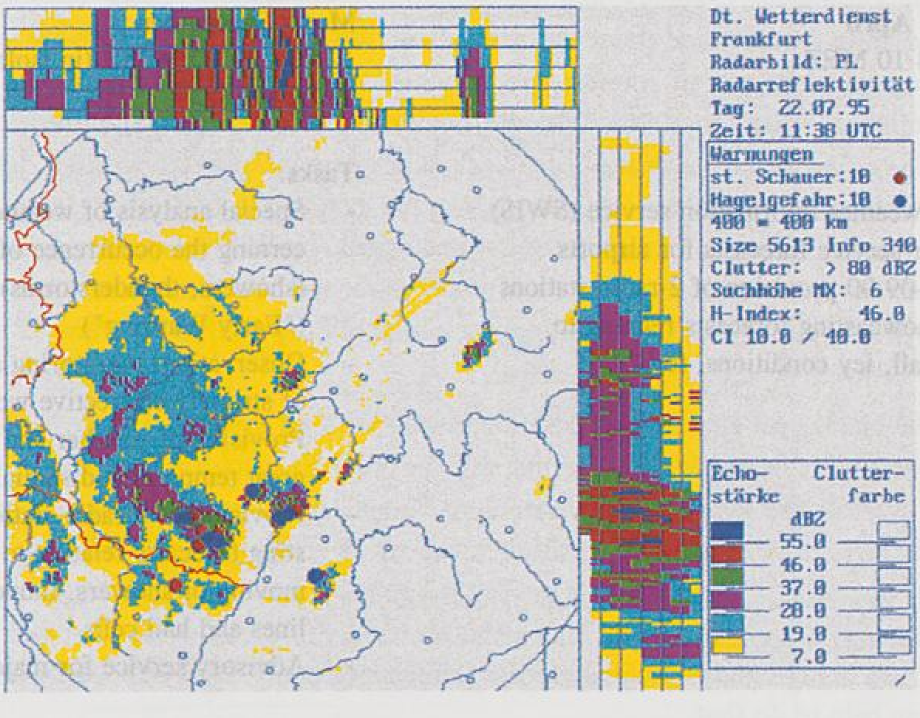

Fig.4 : Radar-image of Frankfurt/M 22-07.95 11.38 UTC. The moment of the Heidelberg hail-storm. To the west the approaching squall-line can be seen.

The case of the Heidelberg hailstorm is to a wide extent typical for problems and the range of success in nowcasting severe thunderstorms in Central Europe. Early warning on the basis of the numerical output and the instability analysis of sounding data normally tend to give a fair indication of what could happen at the actual day. But problems frequently arise with nowcasting regional or local details. If clear mesoscale squall lines are existing, linear extrapolation of local arrival times even 2-4 hours ahead are in many cases possible. But isolated cells or clusters have as a rule no good chance to be nowcasted well in reasonable time in advance. Taking into account quantitatively non-linear cell-evolution by using conceptual models of deep convection has to be the next step to further improve nowcasting of severe local storms, as is already partially realized in automated nowcasting projects, for instance in the British Met Office (Gandolf, Nimrod) or National Weather Service NOAA USA (Thunderstorm-Auto-Nowcaster). With a better objective basis severe weather warning can be more directly tailored to the special needs of local emergency services and users.

FIRST EXPERIENCES WITH A NOWCASTING SERVICE AT OUR REGIONAL CENTRE IN LEIPZIG

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ABSTRACT

A nowcasting shift was set up at the Regional Centre in Leipzig in May 1996. Tasks and working hours differ greatly between summer and winter:

October - April
05.40 - 14.10 MEZ

Tasks:
- Road weather information service (SWIS)
- Winter service forecasts for airports
- 06.00-09.00 provision of 2 radio stations with nowcasting forecasts relating to snowfall, icy conditions, fog

May - September
12.00 - 20.00 MESZ (in isolated cases up to 23.00 MESZ)

Tasks:
- Special analysis of weather conditions concerning the occurrence of strong convection (showers, thunderstorms) ("Early Warning")
- Observation, monitoring and extrapolation of strongly convective weather occurrences
- Provision of weather and storm warnings in great temporal and spatial detail
- Provision of 3 radio stations with nowcasting forecasts relating to occurrence and moving of showers, thunderstorms, gust lines and hail cells
- Advisory service for major open-air events

For the "Early Warnings" phase a check list was worked out against which measured values (Synops, Temps and derived quantities) and model prognoses from the EM and DM regarding the occurrence of strong convection are checked. Essentially the following are checked:

- Temperature difference between 850 and 500 hpa
- Total totals-Index (TT)
- KO Index
- S Index
- Instability energy
- Liquid water content (PPW)
- Differences in the pseudopot. temperatures between 900 and 500 as well as 900 and 300 hpa
- Release temperatures
- Surface airflow (cyclonality, convergences)
- Vorticity and vorticity advection
- Thermal advection
- Surface pressure tendency

We do not, however, have the capacity for continuous verification of the success or failure of the "Early Warnings". Previous subjective assessments have shown, however, that most of the thunderstorms were recognised correctly, but that the question of the local restriction of their origins cannot be resolved satisfactorily. The extrapolation of the movement of existing convective cells is also a lot less successful than at first expected.

Compared to the standard weather reports, there is a decidedly positive response to the nowcasting forecasts from the radio stations. They are obviously in accordance with the need for topicality by both the programme editor and the listeners themselves.

A 1-Dimensional Model for Nowcasting of Hazardous Weather Events.

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Nearly all parts of weather prediction are possible automatically, using numerical and statistical forecast material. But **Nowcasting** (up to two hours) and **Very Short Range Forecasting** (up to 12 hours) remains a man-machine-mix. In co-operation with the German National Weather Service (DWD) our Working Group is preparing a 1-dimensional modular model which will provide many parts of Nowcasting including **Monitoring** automatically in order to enable the forecaster to do proper decisions. A somewhat similar system for the USA has been described by Eilts et al. (1996).

Many meteorological elements like temperature, precipitation, gusts etc., and computer derived information like vorticity and thunderstorm indices, advection rates, probability values etc. of nearly all meteorological elements of interest are processed and displayed **by means of statistical model interpretation** (Knüpffer, 1996). This information is available, already, in the German Weather Service systems. But there are missing the "hard" values concerning extreme weather, i.e. weather hazards like maximum gusts, large amount of convective rain, conditions of flash floods, hail, and - in winter - sudden turning of rain into snow or of glaze conditions. In the DWD systems, "warning points" like hail heads derived from satellite cloud top temperature and thunderstorms, derived from observations, especially from lightning location systems are available from monitoring, now.

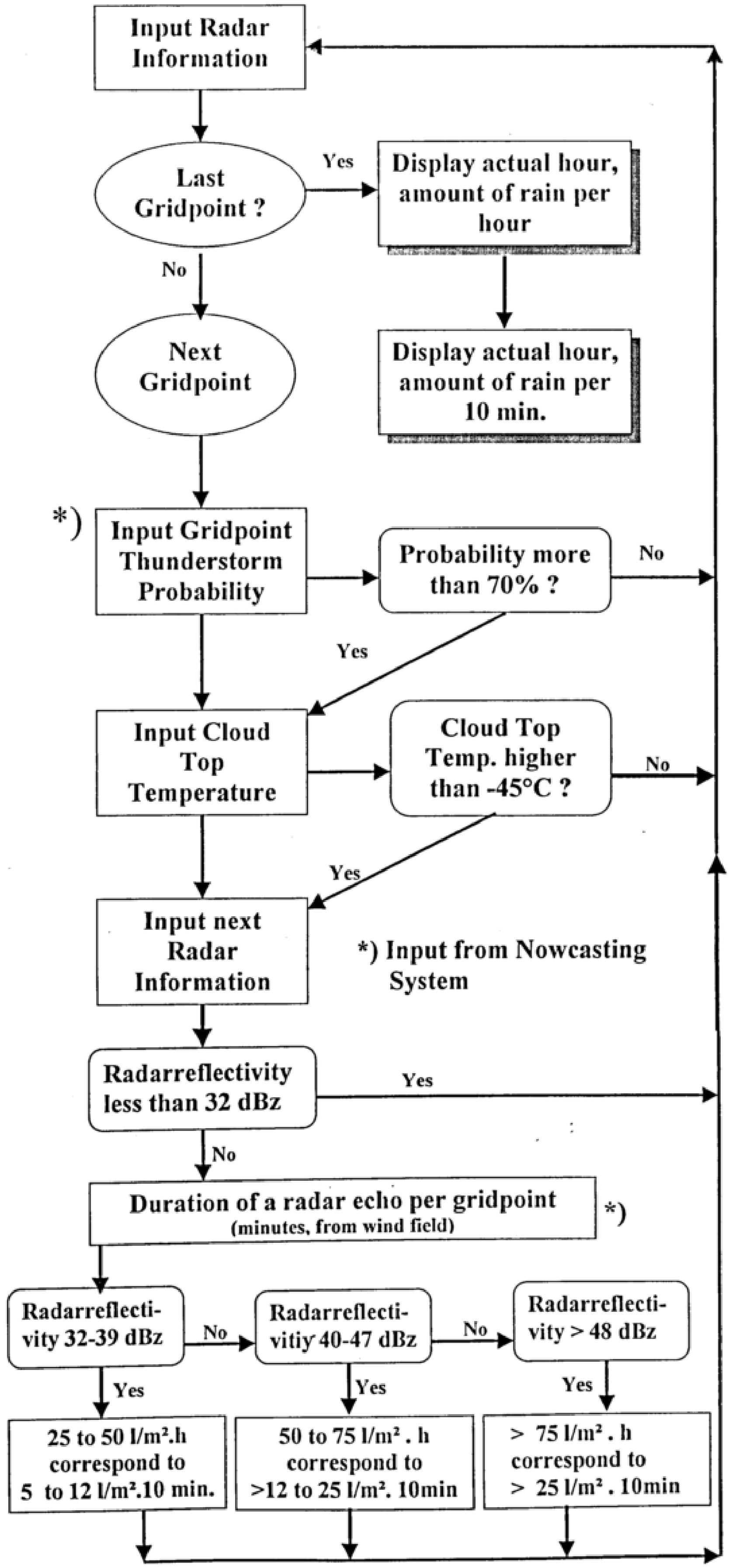
We are developing an empirical system, combined with all available Direct Model Output (DMO) and Model Output Statistics (MOS) information, in order to catch the - **seldom - occurring hazardous weather events**. The goal of that system is to obtain objective and nearly automatically derived values of e.g. rain rates or of maximum squalls. The following conditions should be possible:

First, our model uses all meteorological observations (satellite, radar, radio sounding, synop, metar, speci, lightning). Supplementary, 1-dimensional convection models (e.g. van der Veen & Feijt, 1997) or thunderstorm indices and hail climatologies (Huntrieser et al., 1997) can easily be included. A **COST78 action** may help to do that.

Second, most of these observations are available **asynchronously**, and therefore it must be possible that the model starts and works automatically at every time when new information is coming in or the forecaster wants to use it.

Third, the system has to include the regional climatological background and orographic influences, e.g. the main distribution of thunderstorms, i.e. high numbers in hilly areas and less occurrences in lake areas.

Nowcasting heavy rain, actual hour



Fourth, the forecaster has to use for nowcasting **both the automatically provided monitoring** and the **numerical guidance**, esp. the fine-mesh forecast model output, available every three hours of the forecasting period, interpolated to every single hour. If these two parts are matching, the forecast will be easy. But if differences occur defined thresholds make up alertness, and the forecaster has to decide wether a hazardous situation is expected or not: He has to adjust the forecast, at least. This model has been developed, and first modules are tested within the German Weather Service MAP (Meteorological Work Station System, see Lesch et.al, 1997, this volume).

We use **flow diagrams** in nowcasting convective rain rates, for example (s.Fig.):
If there is a thunderstorm probability of more than 70%, and if a cloud top temperature less (colder) than -45°C is derived from a satellite, and if radar reflectivity exceeds 24 dBz the algorithms may result in maximum rain rates of more than 75 l/m² per hour or - alternatively - of more than 25 l/m² per ten minutes. If satellite or radar information is missing, the flow diagram does work, nevertheless. Included is an algorithm asking for the duration of a rain echo at every gridpoint. This information has to be delivered from a special system which extrapolates and develops (or decreases) the precipitating area especially with the advection of lifting (or sinking) air, derived from the guidance model. Radar and satellite information is processed using the scheme of the Deutschland-Modell of DWD gridpoint by gridpoint.

First verifications using some cases of the summer season 1996 show reliable results - but, firstly, most of the rain cases did not hit synoptic stations, and, secondly, such convective precipitation has a duration of less than one hour - the synoptic readings normally cover six hours.

Literature:

Eilts, D.M.et al. (1996): „Severe Weather Warning Decision Support System", Prepr. 18th Conf. on Severe Local Storms, San Francisco, AMS, Boston, p. 536 - 540.

Huntrieser, H. et al (1997): "Comparison of traditional and newly developed thunderstorm indices für Switzerland", Wea.&Forec., Vol.12, No.1, pp 108-125.

Knüpffer, K. (1996): "Methodical and predictability aspects of MOS systems", Prepr. 13th Conf. on Probability and Statistics in Atm. Sci., San Francisco, AMS, Boston, 8 p.

Lesch, L. et al (1997): "A 1-dim operational nowcasting model for Germany (modular topology and results)". This volume.

Van der Veen, S. et al. (1997): "Cloud detection in a short range cloud prediction model using Meteosat and NWP model data", submitted to J.A.M.

FORECASTING AND SURVEILLANCE OF ADVERSE ATMOSPHERIC PHENOMENA. OPERATING ACTIVITIES IN SPAIN

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ABSTRACT

The geographical situation of Spain, its mountainous terrain and the great influence of masses of warm, humid air from the Mediterranean give rise to the development of a large number of adverse phenomena such as torrential rain, strong winds, storms at sea, cold and hot waves, sudden snowfalls in unusual areas or severe storms.

The Spanish National Meteorological Institute (INM) is aware that the top priority of any meteorological service must be the protection of lives and property and has therefore been devoting its efforts for many years now to the prediction and vigilance of such phenomena. This can be seen in the thorough modernisation of its observation and computing infrastructure, the use of very high resolution numerical models, the implantation of meteorological surveillance activities and the establishment of various specific campaigns for some of the most important adverse phenomena. The aim has been to ensure correct technical and operational activity as well as optimum levels of coordination and collaboration with the Spanish Civil Protection Authorities both at central administration level and at the level of the Autonomous Communities.

The experience gained over many years in the design and organisation of this type of campaign led to the conclusion that it was necessary to set up a unified and integrated forecasting and surveillance system for all types of adverse atmospheric phenomena which should be applied year round, and that special account should be taken of the sensitivity and needs of those social sectors that are most affected by such phenomena. The result of this was the implementation in December 1996 of the National Plan for the Prediction and Vigilance of Adverse Meteorological Phenomena.

An important stage of this Plan was the determination on a national, regional, provincial and sometimes even a local scale of the thresholds for considering when an atmospheric phenomenon becomes an adverse phenomenon. This determination was the result of a study carried out by the INM and the Civil Protection authorities and it is reviewed periodically as new data become available.

The Plan provides for the transmission of short-term warnings when prediction indicates that there is a fair degree of probability that the reference thresholds for a specific phenomenon and place will be exceeded. The situation is then monitored continuously in order to confirm and give further details on the information or to cancel it if the prediction is not confirmed. Once the phenomenon in question begins to develop, continuous monitoring is carried out on it using data obtained from teledetection and automatic stations, in compliance with a pre-determined vigilance strategy. All these operational activities are carried out by the eleven INM Regional Centres for Prediction and Vigilance throughout Spain under the

general coordination of the National Prediction Centre in Madrid.

From 1 December 1996 when the Plan started until the end of May 1997, the INM has issued about 1000 warnings of adverse phenomena. Not all of them, however, indicated serious situations but in many cases reflected low thresholds established in some areas where those responsible were keen to be punctually informed on any phenomenon that might represent some degree of risk.

Although the warnings issued through this Plan are also distributed amongst other organisations that are clearly affected by such phenomena, such as energy generators or transport companies, it has become increasingly clear that specific plans need to be drawn up for some of these users. For this purpose, specific thresholds need to be set up as well as real-time contacts between predictors and the various operators. The INM has signed an agreement with the national railway network (RENFE) to draw up a specific plan for prediction and surveillance to meet the needs of railway transport. The first activities carried out are in connection with the forecasting and surveillance of torrential rain, high temperatures, snowfalls and ice formation on catenaries.

DATA FUSION FOR STORM NOWCASTING FROM WEATHER RADAR AND TOTAL LIGHTNING ACTIVITY

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1. INTRODUCTION

This paper presents results of the design of storm nowcasting concepts developped by Dimensions within the European project 4midable (4D Meteorological Information Data Bases linked across Europe) for DGVII Transports.

2. OBJECTIVES OF DATA FUSION

The objectives of data fusion for storm nowcasting are :

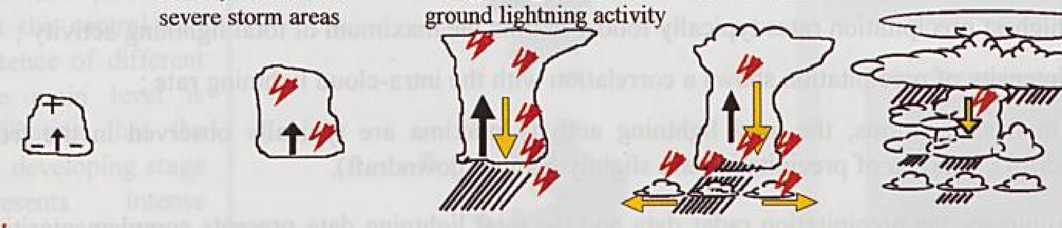
↳ to combine the complementarity informations from weather radar and total lightning observation in order to improve and enrich the information made available to the user.

↳ to synthesize the results of this combination in order to display an information which is easy to interpret and use.

3. COMPLEMENTARY BETWEEN WEATHER RADAR AND TOTAL LIGHTNING OBSERVATIONS

The conclusion of a review of observation systems was to select precipitation radar and total lightning observation because of their complementarity and capacity to provide information with a time (≤ 5 mn) and spatial resolution (~ 1 km) which is adapted to the scale and rapidity of evolution of storm phenomena. This choice has also the advantage to rely on existing technologies in Europe.

STORM PHASE	**BIRTH**	**DEVELOPMENT**	**MATURITY**	**DECAY / DOWNBURST**	**DISSIPATION**
	• Beginning of electrification mechanisms	• Beginning and intensification of Intra-cloud lightning activity with storm development • Intra-cloud lightning activity reveals the severe storm areas	• Intra-cloud lightning activity culminates with maximum vertical development of thundercloud • Beginning of cloud to ground lightning activity	• Intra-cloud lightning activity decay precede downburst phenomena • Cloud to Ground lightning activity culminates	• Some intra-cloud lightnings can remain



PRECIPITATION RADAR OBSERVATION	**NULL OR WEAK**	**WEAK**	**MEDIUM**	**HIGH**	**MEDIUM OR WEAK**
TOTAL LIGHTNING OBSERVATION	**NULL OR WEAK**	**MEDIUM**	**HIGH**	**MEDIUM**	**WEAK**

Figure 1 : Precipitation radar and total lightning observations versus storm phase

The reason for using total lightning observations is that it provides an information as soon as lightning occurs in the cloud ; it is complementary to the precipitation radar information since it indicates the areas in the cloud where lightning activity is occurring due to intense convective activity and high densities of hydrometeors.

Only the use of total lightning activity can provide the necessary early information for storm nowcasting, because, on the contrary of cloud to ground lightning activity, it occurs as soon as the storm develops, and its intensity is related to the storm cell severity.

Typical evolutions of total lightning activity and radar reflectivity with the different storm phases are illustrated in figure 1.

Figure 2 presents an example of thunderstorm observation with precipitation radar and total lightning system (both images are at the same scale : pixel size is 1x1 km, time window is 5 min.). It illustrates the complementarity between the two types of informations :

↳ the radar data is spatially complex, precipitation areas extend over a large zone and present a rather important spatial fluctuation.

↳ the total lightning activity is more concentrated and reveals the areas of electrical activity and strong convection within larger precipitation zones. The southern thunderstorm cell is clearly identified on the total lightning mapping but cannot be identified within the precipitations in the same area.

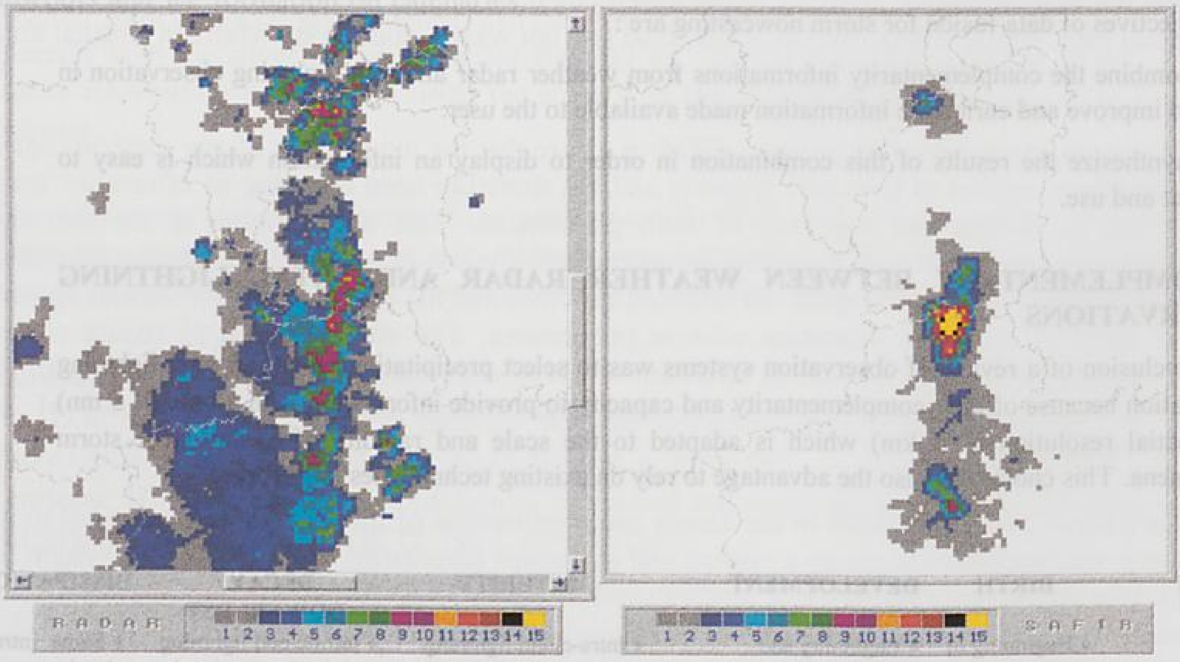


Figure 2 : Complementarity between weather radar (left) and total lightning mapping from SAFIR system (right)

During storm evolutions it is also observed that :

↳ highest precipitation rates typically follow in time the maximum of total lightning activity ;

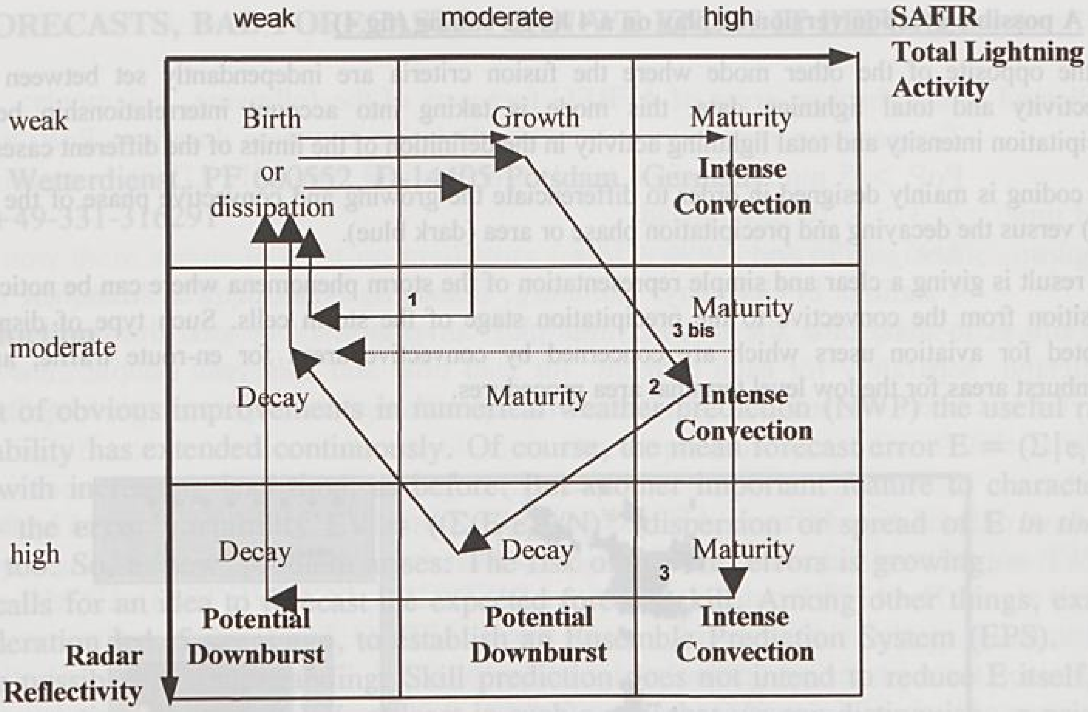
↳ intensity of precipitation shows a correlation with the intra-cloud lightning rate ;

↳ in frontal storms, the total lightning activity maxima are typically observed in the frontal part (updraft), maxima of precipitation are slightly behind (downdraft).

In summary the precipitation radar data and the total lightning data presents complementarities in time and space which can traduce the phases of the storm phenomena. This complementarity is at the base of data fusion principles that we present hereafter.

4. SYNTHETIC CODING FOR DATA FUSION

A first step for data fusion is to define independant synthetic coding scales for precipitation radar data and for total lightning data according to 3 levels : weak, moderate, high. Values have to be chosen to give a representative though simplified image of the intensity of the respective phenomena. We can then define a table of combination of the two informations, comprising 9 cases associated with the storm phase and intensity as presented in diagram 1. A storm cell, during its development, shall describe a cycle within the diagram which shall depend on its severity.



1 - weak or moderate storm - 2 - strong storm - 3 - severe storm (3 bis : « dry » case)

<u>Diagram 1</u> : Storm phase and intensity versus Radar and SAFIR total lightning activity
Synthetic storm life cycles diagram

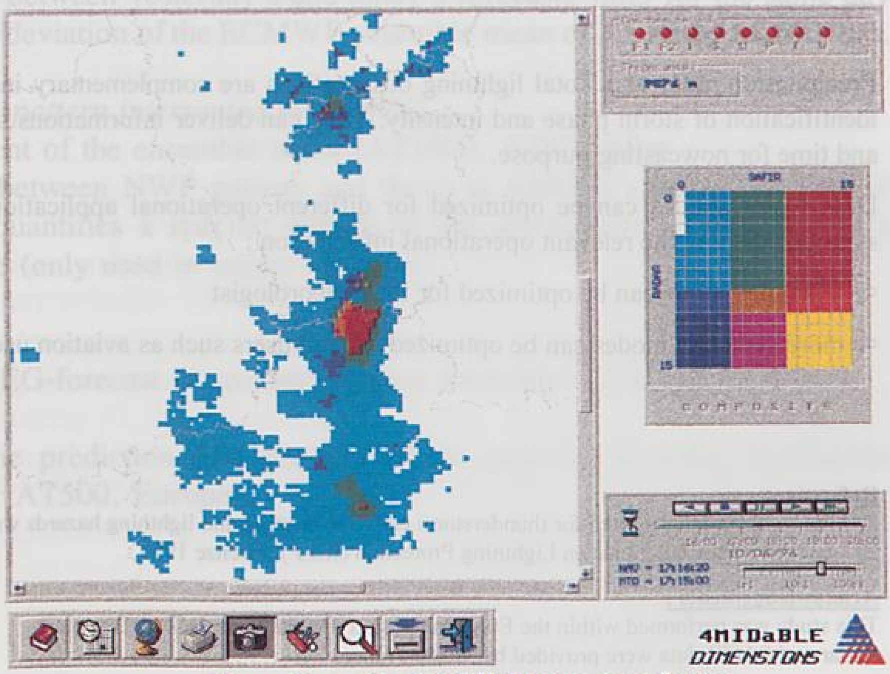
The objective of the synthetic coding is then to derive from this table a synthetic coding, with the minimum number of cases, able to satisfy the nowcasting objectives for different applications and end-users. We present two examples of synthetic coding :

4.1. <u>A possible meteorological version display on a 9 levels coding (fig 3)</u>

This is the most complete coding based on the respective 3 levels coding of radar reflectivity and total lightning data. The non significant low level radar pixels without lightning activity are not displayed ; it has the advantage of giving a synthetic though sufficiently detailed information about the different storm areas and cells in the storm phenomena, including the phase and intensity of the storm.

We can in particular observe in the central cell the coexistence of different levels, the main level is brown indicating that the cell is in a developing stage and presents intense lightning active updrafts with weak precipitations, blue levels in the rear part are indicative of downdraft associated precipitations.

The southern cell is clearly identified as a developping cell.



<u>Figure 3</u> : radar-total lightning data fusion
A possible Meteorological version display

4.2. A possible aviation version display on a 4 levels coding (fig 4)

At the opposite of the other mode where the fusion criteria are independantly set between radar reflectivity and total lightning data, this mode is taking into account interrelationship between precipitation intensity and total lightning activity in the definition of the limits of the different cases.

The coding is mainly designed in order to differenciate the growing and convective phase of the storm (red) versus the decaying and precipitation phase or area (dark blue).

The result is giving a clear and simple representation of the storm phenomena where can be noticed the transition from the convective to the precipitation stage of the storm cells. Such type of display is adapted for aviation users which are concerned by convective areas for en-route traffic, and by downburst areas for the low level terminal area procedures.

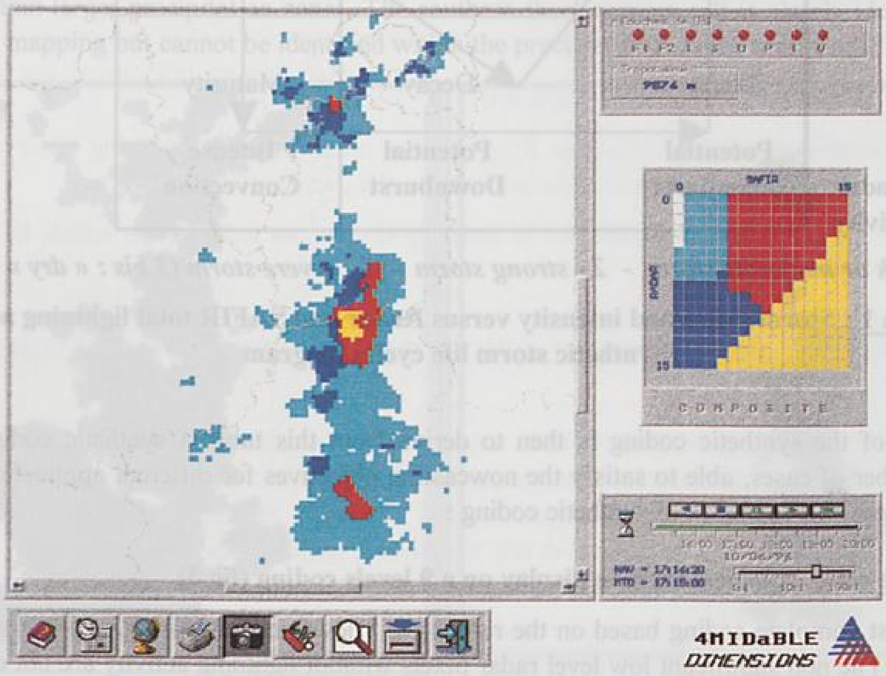


Figure 4 : radar-total lightning data fusion
A possible Aviation version display

5. CONCLUSION

Precipitation radar and Total lightning observations are complementary informations which enable the identification of storm phase and intensity. They can deliver informations sufficiently resolved in space and time for nowcasting purpose.

Data fusion modes can be optimized for different operational applications in order to provide on a synthetic display the relevant operational information :

⇨ a detailed mode can be optimized for the meteorologist

⇨ more synthetic modes can be optimized for end users such as aviation users.

References
SAFIR, an operational system for thunderstorm early localization and lightning hazards warning. 23rd International Conference on Lightning Protection (ICLP), Firenze 1996.

Acknowledgements :
This study was performed within the European project 4Midable for DGVII Transport.
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GOOD FORECASTS, BAD FORECASTS - CAN WE KNOW IT BEFORE?

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1. Introduction

As a result of obvious improvements in numerical weather prediction (NWP) the useful range of predictability has extended continuously. Of course, the mean forecast error $E = (\Sigma|e_i|)/N$ increases with increasing lead time, as before. But another important feature to characterize forecasts - the **error variability** $EV = ((\Sigma(E-e_i)^2/N)^{1/2}$ (dispersion or spread of E *in time*) - increases, too. So, a 'new' problem arises: The risk of 'severe' errors is growing.
This fact calls for an idea to forecast the expected forecast skill. Among other things, exactly this consideration led, 5 years ago, to establish an Ensemble Prediction System (EPS).
To avoid a possible misunderstanding: Skill prediction does not intend to reduce E itself, but its troublesome time-dependent EV, at least in such a way that we can distinguish - a priori! - between 'good' forecasts and 'poor' ones.
Obviously, there are two quite different approaches to attain this aim. First, to find out relevant predictors which correlate with the error e_i, so we can predict it. Second, we can try to reduce the model's mean forecast error E and by this, indirectly, to diminish EV, too.
We should emphasize that we investigate errors in foreasting *local weather elements*, and not broad scale circulation pattern like AT500 or 1000 hPa, as it has been usual.

2. List of (potential) predictors x_i

Information from different kinds of spread:

- x_1 inconsistency between 4 local weather forecasts produced by AFREG interpretation of the following NWP-models: DWD, ECMWF, UKMO, NCEP
- x_2, x_3 inconsistency in time between yesterday's and today's forecasts valid for the same day
- x_5, x_6 EPS spread: Standard deviation of the ECMWF ensemble mean of AT1000, AT500 hPa.

Information about circulation pattern interpreted by AFREG

- x_7, x_8 Mean pressure gradient of the ensemble mean (AT1000, AT500 hPa)
- x_{10} Measure of analogy between NWP pattern and those in AFREG's historic AT1000/ AT500-archive. x_{10} quantifies a specific pattern in the atmosphere's behaviour as a 'typical' or 'rare' one (only used in winter sample).

Information from forecasts

- x_4 'Persistence' of AFREG-forecast (forecasted change from day n-2 to day n, n = 2 ... 10)
- x_9 Daily NCEP real-time prediction (via internet) of the expected anomaly correlation coefficient (PAC) for AT500, Europe

3. Predictands

Predictand is the absolute error of AFREG-forecasts of the following 7 elements:

Temperature maximum minimum, Relative sunshine duration, PoP > 0 mm/d, PoP > 5 mm/d, surface wind direction and speed (12 UTC)

Lead time: 2, 3, ..., 10 days ahead

Samples: 4/96 - 9/96 and 10/96 - 3/97

4 stations in Germany: Hamburg, Potsdam, Frankfurt/M., München

The aim is to determine the (linear, multiple) correlation **r** between the predictors and the predictand, separately for each element, for lead time and half year sample. The regression analysis has been carried out with a statistically stable screening regression method without artificial skill.

We have defined two different AFREG strategies in order to study advantages by interpreting 4 NWP-outputs and then making a **MIX-consensus** forecast instead using a single output (EC-model) alone. The 4 NWP outputs come from DWD(GM), ECMWF(T213), UKMO and NCEP. Additionally to the simple-averaging of the 4 AFREG local weather forecasts, we have determined the a-posteriori *optimal* weight of each model. Finally, reductions of both E and EV by means of both mixing and forecasting forecast skill regression analysis have been calculated and compared with using a single model.

4. Results

- Model inconsistency (x_1) is the best predictor to estimate *local weather* forecast errors. This result corresponds well with other investigations to predict skill of *circulation pattern* forecasts. The next important predictors come from EPS spread information (x_5, x_6), but only for the MIX-forecasts. The second place predictor in using a *single* model (here: EC) does not come from EPS, but from a pattern's feature (x_7). NCEP's PAC predictor x_9 hardly contains a prognostic information for Central Europe.
- Spread-skill correlations exist, but correlation coefficients are rather small. Unexpectedly, r depends on the weather element we want to predict. Its mean value between day 2 and day 7 ranges from 0.14 to 0.41, that means:
  Only 2 - 17% of the total error variance can be explained by some predictors, 83 - 98% are caused by unknown predictors ... or by chance.
- Fig. 1 gives us answers about possible reduction of error variability by
  - skill prediction for a *single* model (EC): A
  - mixing 4 models: B
  - mixing 4 models plus skill prediction: C

  The base line (y = 0) represents both error and error variability of a *single* model (EC) without skill prediction. Note that most of the desirable reduction of error variability EV comes from the mixing concept. Its effectiveness increases (linearly) with increasing lead time. The additional amount by skill prediction seems to have a maximum around day 3/day 4. Beyond this range its influence decreases.
- The line D shows the mean effect of skill improvement by mixing with 2 models (GM, EC) and with 4 models (GM, EC, UK, NC), respectively (E).
- Averaging was carried out with equal weights for each model. The 'real' a posteriori optimal weights don't differ dramatically.

The results from the second sample (10/96) - 3/97) will be presented at the conference.

5. Conclusions

- Up to now there seems to exist no predictors for skill prediction, being sufficiently good enough for practical application purposes.
- But, consequent mixing of NWP outputs from several centers is a very interesting way to 'kill two birds with one stone':
  (1) Improving forecast skill by reduction of mean error E *a n d*
  (2) Significant reduction of its troublesome time-dependent variability EV.
- Forecast inconsistencies - both from day to day and between different models - are difficult to handle for the forecasters who need to avoid conveying abrupt changes of their forecasts to the public. The best way to overcome the temptation to over-estimate a single model's guidance is - mixing!
- As long as no real dynamic-stochastic weather prediction model is running operationally, mixing several **different models** can simulate, for the present, the stochastic nature of our *imperfect* weather forecast *equations* - as EPS does concerning the *imperfect initial state.*

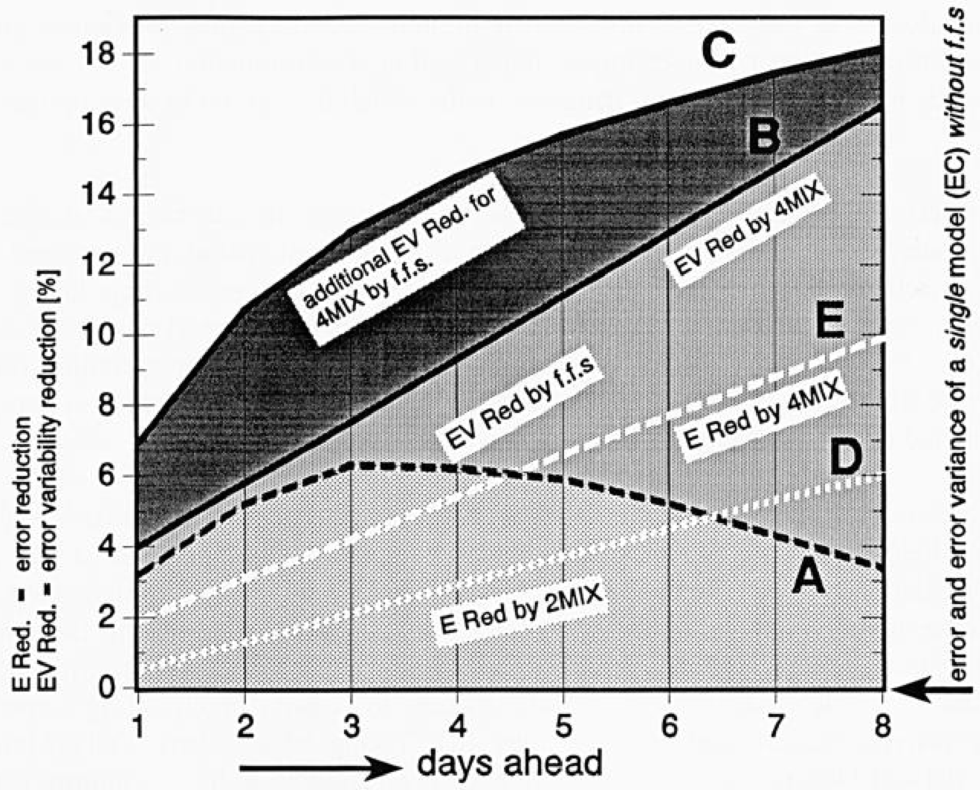

Fig. 1 The effects of skill prediction regression anlysis and model mix (2MIX, 4MIX) on reduction of both forecast error variance (A, B, C) and forecast error (D, E)

Medium-range AFREG-forecasts for 7 elements an 4 stations in Germany (4/96 - 9/96)

THE DEVELOPMENT AND OPERATIONAL TRIAL OF A RADAR-BASED, AUTOMATED NOWCASTING SYSTEM DESIGNED TO PREDICT HEAVY CONVECTIVE PRECIPITATION: THE *GANDOLF* PROJECT.

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ABSTRACT

Three years ago, an R&D project was established jointly by the UK Met. Office and the Environment Agency (EA; responsible for inland flood warning in the UK) to develop an automated nowcasting system for the prediction of heavy, convective precipitation. A prototype version of this system, called GANDOLF (Generating Advanced Nowcasts for Deployment in Operational Land-based Flood forecasts), has been undergoing operational trials in the Met. Office (Pierce et al.,1995).

The temporal and spatial errors in precipitation forecasts tend to be largest at times when their accuracy is most critical to the flood forecaster. This is a reflection of the complexities inherent in predicting the exact timing and location of outbreaks of convective activity. It is often those intense yet very localised convective storms, characteristic of the summer months, that cause major problems for the flood forecaster. Firstly, they can develop extremely rapidly: the transition from a *cumulus humilis* to a towering *cumulonimbus* may take as little as half an hour. Secondly, their movement and development may be markedly non-linear. For example, under certain environmental conditions, existing mature convective cells may develop distinct 'daughter' cells, which then go on to develop into mature storms themselves.

These characteristics of convective activity pose real problems for current, radar-based precipitation forecasting systems. Such systems tend to use data of insufficient spatial and temporal resolution, and their forecast schemes, founded as they are on some form of linear extrapolation, simply advect observed precipitation fields using representative wind vectors or historical motion vectors. While such techniques may be adequate in situations where the area and shape of a precipitation field change little over the period of the forecast (e.g. in some frontal events), they will be unable to cope with the rapid development and decay that routinely occur in convective precipitation fields.

The principle aim of the GANDOLF project is therefore to improve radar-based prediction of precipitation fields during periods of non-frontal convection. To this end, a physically realistic conceptual model of convective cell behaviour has been developed and implemented for automated, standalone operation. This so called Object Oriented Model (Hand, 1996) forms the centre piece of the GANDOLF system (see Figure 1). It employs multiple beam, 2 km Cartesian gridded, 10 minute, C-band radar data and Meteosat infrared satellite imagery to classify precipitating convective cells into one of five convective cell stages: Developing (d), Young Mature (m), Fully Mature (M), Early Dissipating (E) and Dissipating (D). Each cell stage is considered to have a unique vertical profile of rainfall rates, determined by considering the instantaneous values measured in each of four radar beams. The horizontal cross section of a cell varies with stage, and is assumed to be square.

The OOM runs on a 10 minute cycle. Each run commences with a cell instantiation: the classification of convective cells using the latest multiple beam radar data (and satellite data on the half hour and hour). The OOM's forecast scheme takes each of the instantiated cells through a predefined cycle of activity which involves orderly transition through the five cell stages mentioned earlier. The precise nature of this transition or cycle is dependent upon the cell potential. The latter is a measure of the

vigour of the cell and therefore the severity of the convection. Convective cell motion is determined by a representative wind vector whose level varies according to cell stage. The requisite three dimensional wind field is derived from a mesoscale NWP model run at the Met. Office (part of the UK Met. Office's Unified Model).

Despite its simplicity, the OOM forecast scheme is able to simulate the quite complex, non-linear behaviour so typical of evolving convective precipitation fields. For example, during periods of convection characterised by strong vertical wind shear, the OOM is able to model the growth of new convective cells by daughter cell development. The value of this capability has been borne out by some recent summer trial case studies. Comparison of the performance of the OOM with existing, extrapolation-based precipitation nowcasts (e.g. from the UK Met. Office's FRONTIERS system) under such conditions has demonstrated the OOM's ability to improve the spatial and temporal accuracy of convective precipitation nowcasts. It is hoped that these improvements will improve the accuracy of the flood warning issued for the London area by the EA.

The OOM is specifically designed for the prediction of non-frontal convective precipitation. Its conceptual model, founded as it is on the behaviour of discrete convective cells, is not applicable to frontal precipitation events, or cases of frontal precipitation with embedded convection. A principle component of the GANDOLF system is therefore an objective, weather type diagnosis algorithm, designed to distinguish non-frontal convection from dynamically forced (frontal) weather systems. This algorithm combines the information afforded by a neural network-based cloud classifier, and various NWP diagnostic fields, including parcel Convectively Available Potential Energy (CAPE) and convergence. The neural network cloud classifier is a multi-layer perceptron trained to distinguish four categories of cloud system: those that are dynamically forced (dy), shallow convection (sh), deep convection (de), and clear (cl; no cloud, clear land or sea).

The classification provided by the weather type diagnosis algorithm is used as a switch to determine when the OOM is run. During periods of non-frontal convection, OOM forecasts are sent directly to the EA's Flood Control Centre, via a dedicated telecommunications link. When frontal precipitation is observed, the Thames EA is advised to use other radar-based precipitation nowcasts available to them. These include the UK Met. Office's Nimrod system, and the Institute of Hydrology's Local Forecast Model (LFM). This guidance on the choice of forecast is not simply a function of weather type. It also involves consideration of the relative performance of the forecasts available. During periods of non-frontal convection, GANDOLF compares the performance of the OOM and Nimrod in near real time. When errors in OOM forecasts are largest (perhaps due to steering level wind errors), the system will advise the use of nowcasts generated by Nimrod or the LFM. This advice is communicated to the Thames EA's Flood Control Centre in the form of a text message sent every five minutes.

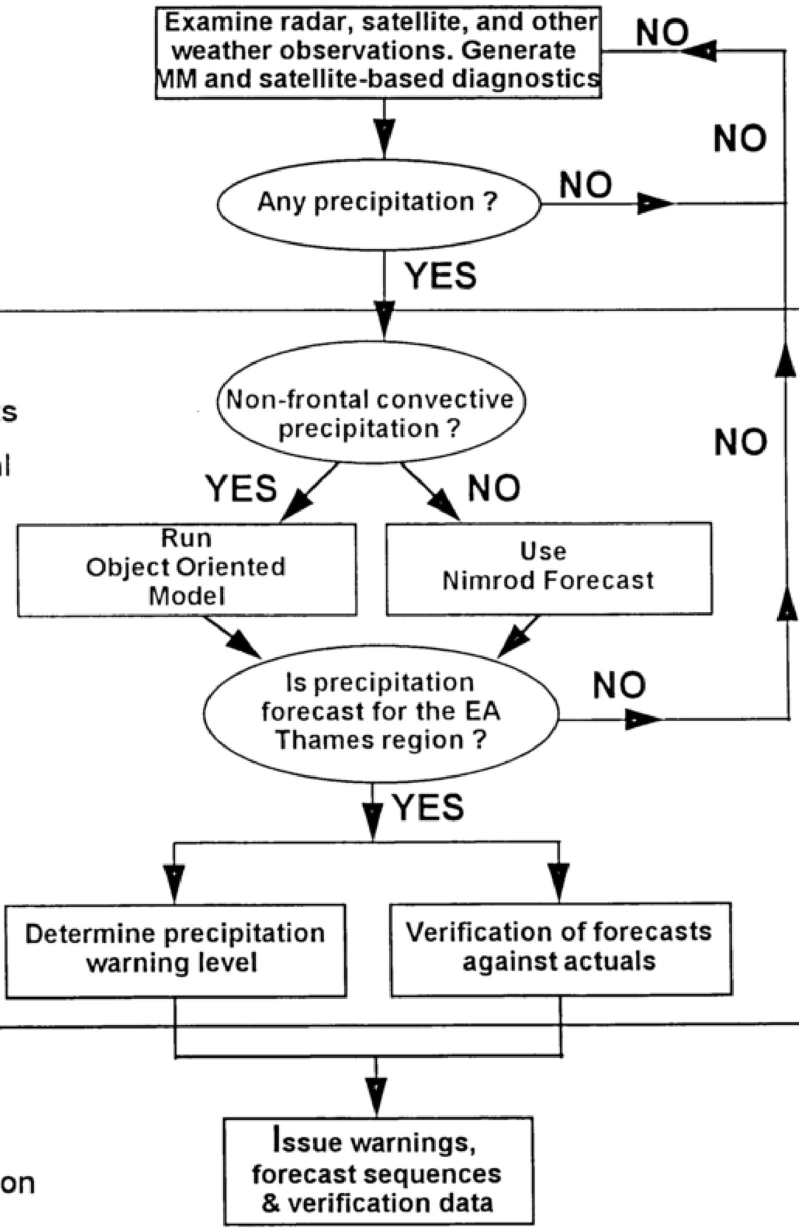
The GANDOLF system is currently undergoing a third summer trial (May to October 1997), after which its potential for operational service, either as a standalone system, or as an addition to the Met. Office's Nimrod system, will be reviewed.

References

Pierce, C.E., Collier, C.G., Hardaker, P.J. 1995. Forecasting of heavy convective rain for use within a flash flood warning system. Fifth National Hydrological Symposium of the BHS, Herriot-Watt University, Edinburgh, 4.17-4.23.

Hand, W.H. 1996. An object-oriented technique for nowcasting heavy showers and thunderstorms. Meteorol. Appl. 3, 31-41.

FIGURE 1 THE GANDOLF SYSTEM



LEVEL 1 : Monitor

Data gathering and processing

- Retrieve data at regular intervals
- Calculate various convection diagnostics
- Identify areas of precipitation in Chenies radar

LEVEL 2: Action

Generation & analysis of convective precipitation forecasts

- Determine whether precipitation is associated with non-frontal convection ?
- Apply the relevant forecast
- Assess the movement of precipitation
- Determine current precipitation warning level

LEVEL 3: Alert

Dissemination of data to Thames Flood Control Centre

- Send coded warnings, Object Oriented convective precipitation forecasts, and verification data

AN OBJECTIVE VISIBILITY ANALYSIS AND VERY-SHORT-RANGE FORECASTING SYSTEM

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ABSTRACT

In 1992, a project was initiated within the United Kingdom Meteorological Office (UKMO) to produce an automated system, which would provide forecasters with the best possible guidance when issuing forecasts in the range 0-6 hours ahead. The system, called Nimrod (Golding, 1997), was to provide analyses and forecasts for a number of meteorological parameters over the UK and surrounding waters, with the forecast slowly merging with the UKMO Mesoscale Model (MM) prediction, to provide continuity beyond six hours.

As part of Nimrod, an objective Visibility Analysis/Forecast System (VAFS) has been developed. The analysis blends satellite imagery, surface observations and a one-hour forecast, using a variational algorithm. The forecast is a combination of a 'trend' forecast, persistence and MM values. This is performed on a 5 km National Grid, and runs hourly, producing forecasts out to six hours, which are available within 30 minutes of data time.

In the scheme, visibility is a diagnostic rather than prognostic variable. The state of the near-surface is characterised by the conserved variables liquid water temperature, T_L, and total water content, q_t, from which visibility is derived using the MM aerosol field. T_L and q_t are defined as follows :

$$T_L = T - \frac{Lq_L}{C_p} \qquad\qquad q_t = q + q_L$$

where T is the temperature, q is the specific humidity, q_L is the liquid water content, L is the latent heat of condensation for water and C_p is the specific heat capacity of air at constant pressure. Visibility can be related to a droplet radius and number density using an equation based on Koschmeider (1924). With respect to visibility, the atmosphere can be divided into two distinct regimes, depending on whether or not the fog droplets have been activated. Unactivated droplets are essentially aerosol particles with a small amount of liquid water, and their mean droplet radius can be related to the relative humidity by the equilibrium equation (Pruppacher and Klett, 1978). Activated fog droplets grow rapidly, and the cloud water content can be related to the mean droplet radius by geometric consideration. In both cases, the aerosol field is used derive the droplet number density, and dry particle radius.

In the analysis, surface observations of visibility, screen temperature and screen dew point are used to derive values of T_L and q_t using the inverse of the visibility diagnosis equations, discussed above. Meteosat imagery (infrared and visible) is used during daylight and AVHRR imagery (infrared and the UKMO 'fog' product (Eyre et al, 1984)) at night to diagnose clear and potentially foggy areas, which are then 'calibrated' using surface observations. As with the surface data, values of T_L and q_t are derived for analysis. The MM provides T_L and q_t directly, and also pressure, aerosol and surface temperature information.

A 'trend' forecast is produced by adding MM trends in T_L and q_t to the analysis values. This is merged with persistence (the analysis) and MM values, to produce the final 'merged' forecast. The weighting of the three merged components is calculated by assessing the relative quality of the '1 hour forecasts' from the previous hour against observations; the relative weights are varied through the forecast period.

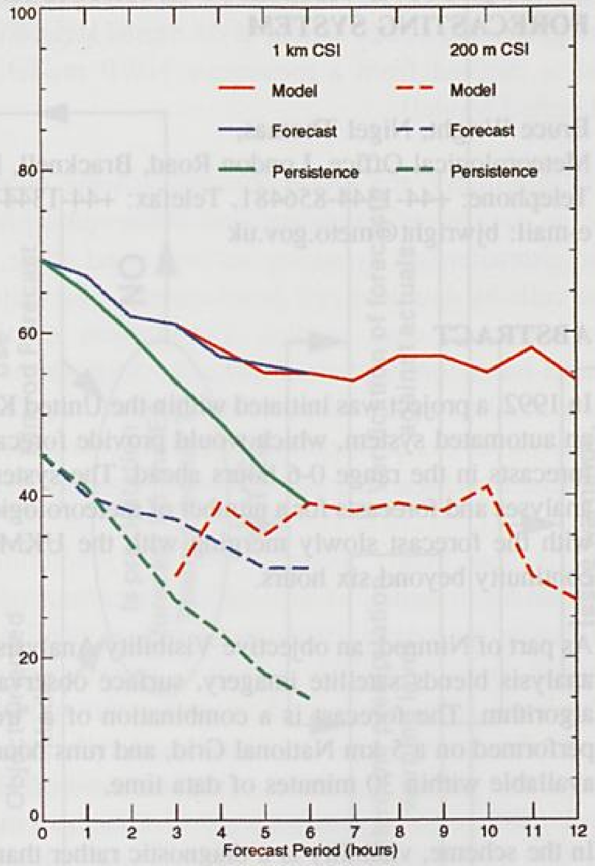

Figure 1 The Critical Success Index at 1 km and 200 m visibility thresholds using an areal assessment against surface observations for the extended case study period.

Detailed assessment of the VAFS has been carried out on an extended case study period (7 days) covering a foggy period in March 1997. Figure 1 shows the performance of the scheme compared against persistence and the MM forecast. The statistics shown are the Critical Success Indexes (CSI) with thresholds of 1 km and 200 m visibility using an areal assessment against observations; the UK is divided into 13 geographical regions, and the 8 lowland areas are assessed as being foggy if 30% of the observations (grid-squares) are below the visibility threshold, or clear otherwise. The forecast out-performs persistence, which tails off sharply, and is better than the MM out to three hours ahead and of a similar quality beyond that. Figure 2 shows an example of forecasts at different ranges for the same time, with the verifying surface visibility observations and Meteosat imagery. The one hour forecast has a lot of structure and a fairly accurate representation of the fog. As the forecast period increases, the accuracy decreases, and the forecast becomes less structured, tending towards the MM prediction.

The VAFS presented here shows considerable promise, offering significant improvements in skill over the corresponding MM predictions at short lead times. However, there are still weaknesses in the system, and work is in progress on a number of areas, including the visibility diagnosis scheme, the inclusion of hill fog using the Nimrod cloud analysis, and the forecast merging procedure.

References

Eyre, J.R., Brownscombe, J.L. & Allam, R.J. (1984). Detection of fog at night using Advanced Very High Resolution Radiometer (AVHRR) imagery. *Meteorol. Mag.*, **113**: 265-271.

Golding, B.W. (1997). Nimrod: A system for generating automated very-short-range forecasts. Accepted by Meteorol. Appl.

Koschmeider, H. (1924). Theorie der horizontalen sichtweite. *Beitr. Phys. Atmosph.*. **12**: 33-53, 171-181.

Pruppacher, H.R., & Klett, J.D. (1978). *Microphysics of Clouds and Precipitation*. D. Reidel Publishing Company, Dordrect, Holland.

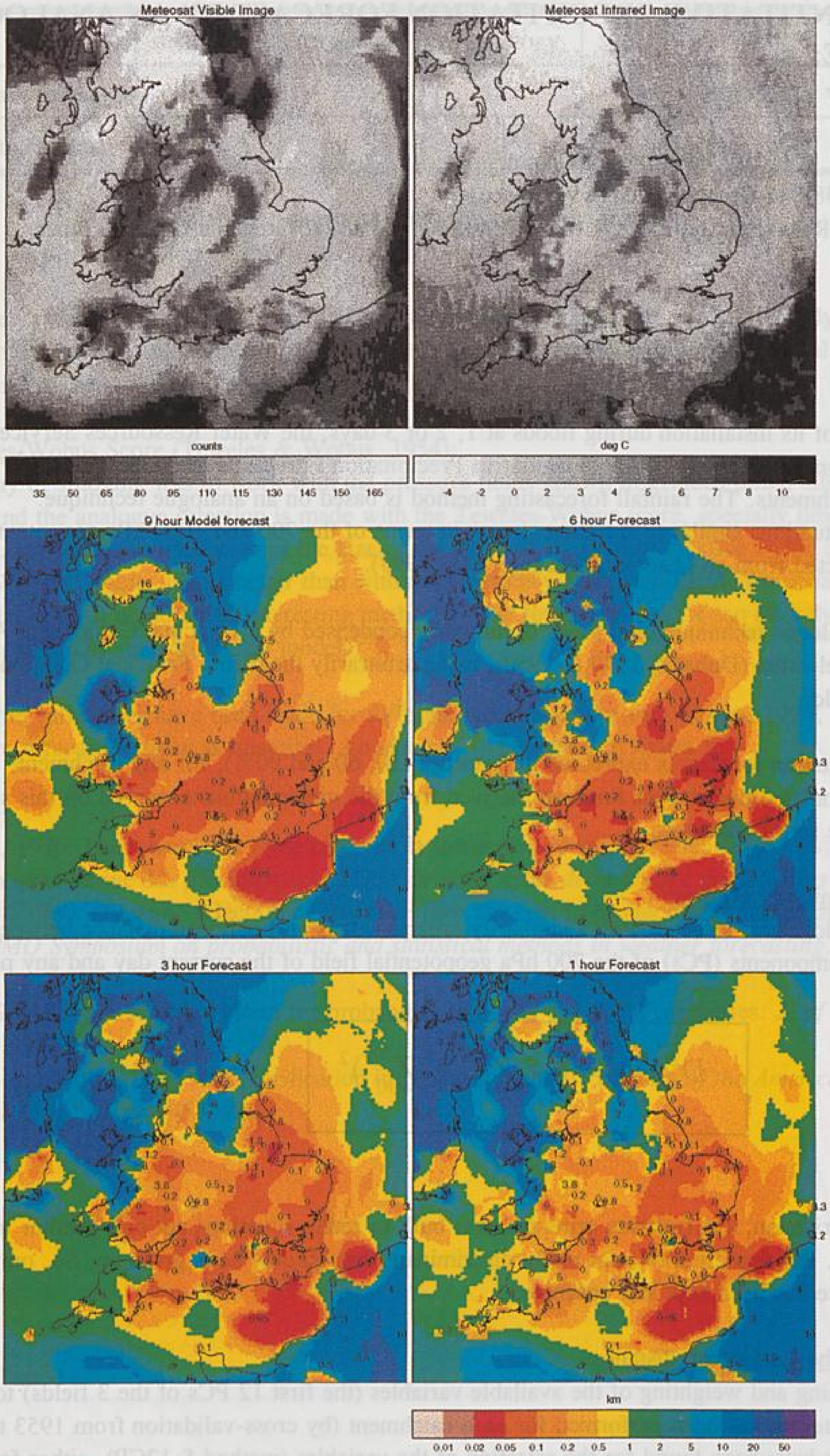

Figure 2 TOP: Meteosat visible and infrared imagery; MIDDLE: 9 hour MM forecast and 6 hour forecast; BOTTOM: 3 hour and 1 hour forecasts. All valid at 0900 UTC, with surface visibility observations overlaid.

DAILY QUANTITATIVE PRECIPITATION FORECAST BY AN ANALOGUE TECHNIQUE:
The similarity criterion

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ABSTRACT

For the security of its installation during floods at 1, 2 or 3 days, the Water Ressources Service of Electricité de France performs a Daily Quantitative Precipitation Forecast every morning on 33 French mountainous catchments. The rainfall forecasting method is based on an analogue technique: meteorological situations similar to the current one, in terms of the 700 and 1000 hPa geopotential fields at 00h, are extracted from an historical data file (1953-1993).

Till now, the analogue technique used fields preliminary condensed by a Principal Component Analysis and 2 levels of selection (Duband, 1970 & 1980), using arbitrarily the 6 first Principal Components (PCs) of each field.

Then, the precipitation forecast is expressed in quantiles (20, 60 and 90%), for any catchment, by fitting the empirical cumulated distribution function, derived from the precipitations observed on this specific catchment for the set of analogues.

<u>The reference similarity criteria</u>:
A first set of analogues is selected with a similarity criterion. It is an Euclidean distance between the 6 first Principal Components (PCs) of the 700 hPa geopotential field of the current day and any past situation J:

$$D^2(J) = \sum_{i=1}^{6} (Z_{iJ}^{700} - Z_{iC}^{700})^2$$

Then, a second criterion, a correlation criterion, was built to retain situations not only similar in distance but also in shape. But that criterion, not really discriminant, has quickly been given up. So, only the Euclidean distance has been kept and optimized.

<u>Optimization of the Euclidecan distance</u>:
Automatic screening and weighting of the available variables (the first 12 PCs of the 3 fields) to be entered in the criterion has been performed for each catchment (by cross-validation from 1953 to 1993). Significant results have been found for the selection of the variables (method S-12CP), either for rain/no rain forecast - with the percentage of correct forecasts - or for probability forecast in 8 classes with the Ranked Probability Score (Epstein, 1968). Some comparisons have been made with standard forecasts like persistance, climatology and with the reference method.

Then, the use of raw data (Radio Sounding data Rs instead of the Principal Components) in the similarity criterion (method S-12RS) has given approximately the same results.
In table 1, results, averaged over the 33 French catchments, could be found:

	reference	persistance	climatology	S-12CP	S-12RS	TW-GR
rain/no rain forecast	72.2	72.8	52.4	78.7	79.2	80.1
probability forecast	.59	.99	.75	.49	.47	.45

table 1: optimization of the similarity criterion

Unfortunately, the weighting of the variables has given nothing interesting. But conversely, by giving more weight to the best analogue situations (smallest Euclidean distance) before the calculation of the precipitation forecasts, the results still become a little better.

The Teweles-Wobus Score (Teweles & Wobus, 1954):
an other way of studying was to work with the pressure fields known in gridded pints, after interpolation. And the analogue selection is made with the Teweles-Wobus score, specially designed for gridded data. After the optimization of the size of the grid and its position relative to the catchments (method TW-GR), results a little better than with the previously optimized Euclidean distance, have been found (cf. table 1). It could be an interesting method for the future, because it can directly use the gridded data given by meteorological models:

Finally, some validations have been made for different catchments during Automns 1994, 1995 and 1996, where forecast is given as quantiles. An example is presented in figure 1.

References:

Duband D., 1970: Reconnaissance dynamique de la forme des situations météorologiques, application à la prévision quantitative des précipitations. *Thèse de 3ème cycle de la faculté des Sciences de Paris.*
Duband, D., 1980: Dynamic selection of analogue flow patterns to produce quantitative precipitation forecast. *WMO Symposium on probabilistic and statistical methods in weather forecasting, Nice, 8-12/09/80.*
Epstein E.S., 1969: A scoring system for probability forecasts of ranked categories. *J. of Appl.Meteor., Vol. 8, pp. 985-987.*
Teweles S. and Wobus H., 1954: Verification in prognostic charts, *Bulletin of the American Meteorology Society, Vol 35, n°10, pp. 455-463.*

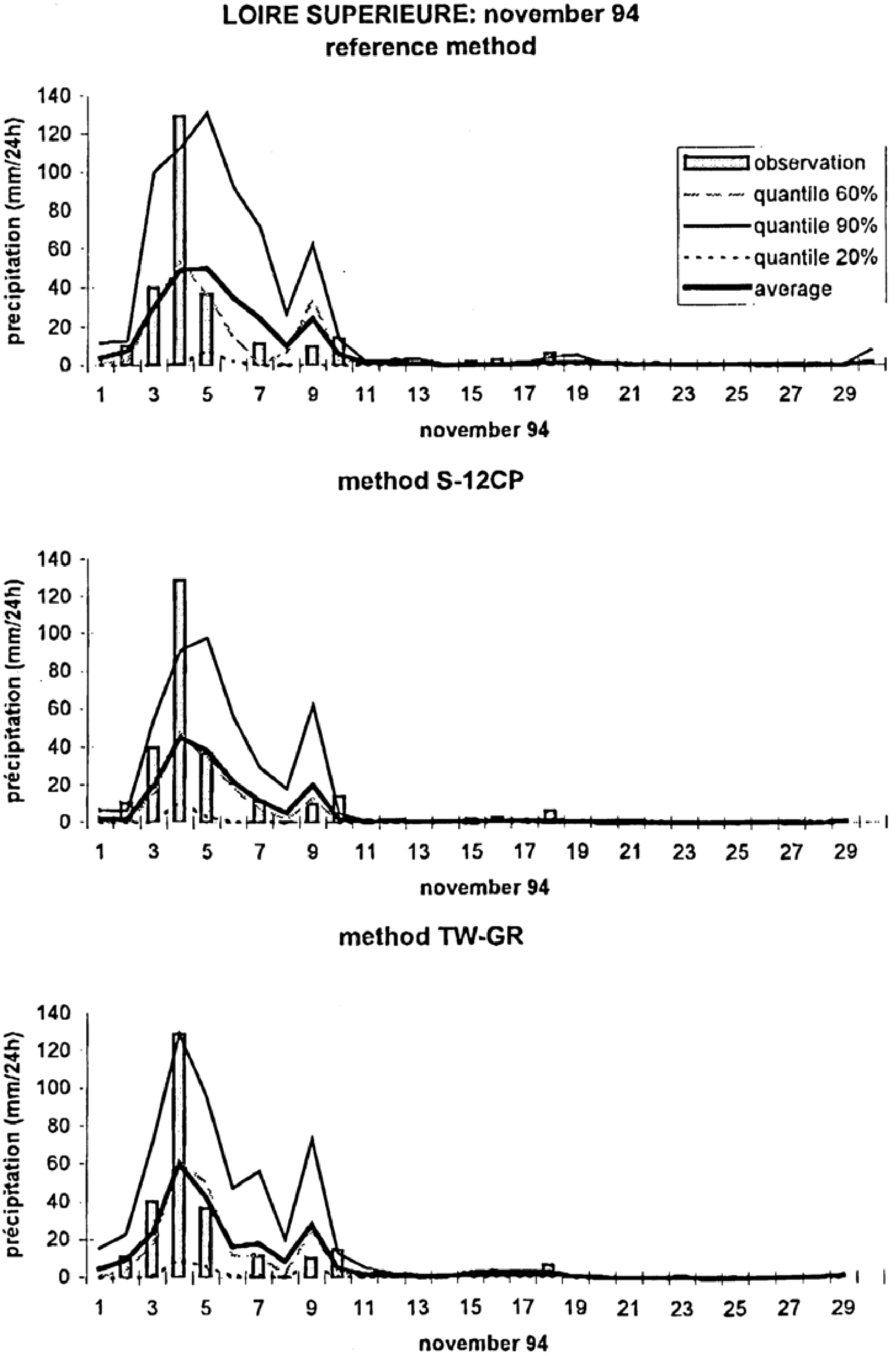

figure 1: example of november 1994 on Loire Supérieure

AN ASSESSMENT OF INSTABILITY INDICES USEFULNESS FOR THUNDERSTORM NOWCASTING

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ABSTRACT

Using a 7 year long data set which includes lightning data, we assess the usefulness of instability indices. This indices are derived from ground data and mid-day soundings, and used for the forecast of thunderstorm occurrences in the afternoon and evening. The method involves discriminant analysis and make use of objective weather types. The best indices are $Adedokun_2$, $Telfer$ and Cape-like indices. They allow for a 35% improvement over a climatological forecast. Persistence forecasts are compared to the mid-day-indices based forecast.

Introduction. Despite the generalization of the operation of Limited Area Models (LAM), instability indices remain useful for practical nowcast of convection: the LAM are only able to simulate crudely the largest convective systems, and may even miss their occurrences, depending on the quality of their initial state and the effective triggering of convection in the model. Knowing the properties of instability indices is also useful when using them as diagnostics computed from LAM forecast. Many index definitions have been proposed in the litterature, mainly validated for the USA; as regards the european region, Collier and Lilley (1994), and Andersson et al. (1989) evaluated some indices, as did Rezacova and Motl (1990) (with also a number of other predictors), but there is no published systematic study. We try to select the best indices for nowcasting at a given site among numerous proposals, and using a comprehensive data set and a statistical approach.

Data and indices used. The geographical domain of the study is a 300 km-side square centered on the Trappes sounding station, near Paris. The period encompasses the "summers" (1 April - 30 october) of the years 1987 to 1994. We hence use 1514 validated mid-day soundings. We use ground data of 59 surrounding stations for those indices which make use of maximum surface temperature.

Thunderstorms are observed using a lightning detection network of the LLP type (Krider et al. 1976; MacGorman and Taylor 1994; Tourte et al. 1988), and setting a lower threshold of three lightning strokes for diagnosing a thunderstorm occurrence in a given time period. On the zone, there were around 95 thundery days each year, and an average value of 600 strokes per thundery day, with little year-to-year variability. Concerning the diurnal variability of thunderstorm occurrences, thundery hour frequencies show a base value of 3% which rises to 6% from 12UTC to 21UTC, and a peak value of 12% around 16UTC.

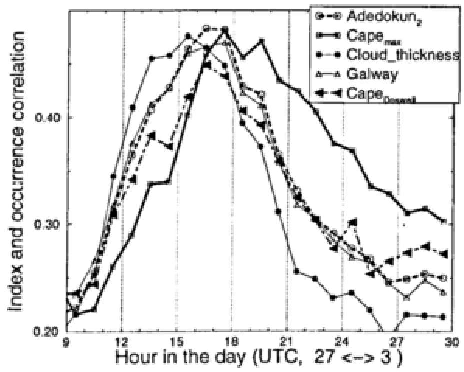
We used 69 indices:

- 18 indices issued from the rising parcel theory (without entrainment): lifted condensation level pressure and corresponding lift (from ground pressure) for three different parcels chosen with average low level characteristics, level of free convection, 4 different flavours of Convective Available Potential Energy (CAPE), convective inhibition, cloud (or updraft) thickness and cloud top pressure;
- 22 indices proposed by the litterature: $Vertical\ total$, $Cross\ total$, $Total\ Totals$ (or Tt, 2 versions), *Showalter* (2 versions), *Galway* (or Lifted index), *Adedokun* (2 versions), $Telfer$, $Faust$, K (2 versions), $Jefferson$, *Deep Convective Index*, $Rackliff$, *Sweat*, *Simila*, *Energy index*, *Instability index* (2 versions)
- and various basic parameters from the soundings, including mean winds and wind shears.

The detailed definitions can be found in Sénési and Thepenier (1997, Peppler and Lamb (1989) [1].

A study of correlation between these indices, together with the results arising from numerous stepwise selections concerning the stability of indices ranking, allow us to restrict the number of indices later used in this study.

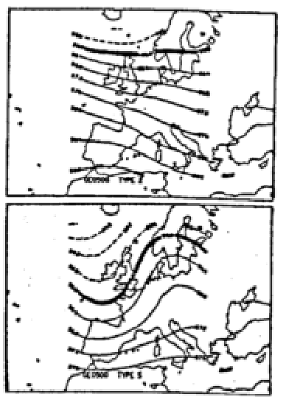
Single-index approach to thunderstorm occurrence. The information content of indices with respect to thunderstorm occurrence has been assessed for various time in the day by computing the correlation between indices values on one hand and thunderstorm occurrences on hourly intervals on the other hand. This shows (see figure) which are the best indices when they are considered separately; most indices show a peak information content in the 15-18 UTC time period. The maximum correlation is 0.48. $Cape_{max}$, which uses maximum ground temperature for the day and the zone, shows better correlations than the other indices for later times. These conclusions remain valid when thunderstorm occurrence is defined by a higher threshold of the hourly stroke number or when correlation is computed using stroke numbers instead of thunderstorm occurrences; correlations are then much lower, and Cape-like indices become the better ones.



Critical thresholds, corresponding to equal empirical probabilities of thunderstorm occurrence and non-occurrence, for the 15-18 UTC time period, show below [2].

$Adedokun_2$	$Faust$	$Galway$	TT_{mod}	$Telfer$	$Cape_{max}$	$Cape_{Doswell}$	$Cloud\_thickness$
0 °	-5 °	-2 °	57 °	70%	1750 J/kg	300 J/kg	400 hPa

Discriminant analysis for thunderstorm occurrence. We used i) discriminant analysis, ii) with the stepwise predictors selection technique (together with a Fisher test for limiting the predictors number), and iii) the jacknife method for sensitivity analysis; we computed discriminant equations for predicting thunderstorm occurrence for various periods of the day.



For the 15-21 UTC period, and assuming an equal cost of one false alarm and one non-detection, the method selects the $Adedokun_2$ and $Telfer$ indices and allows a prediction showing 16.3% misses (while the period shows a thunderstorm frequency of 25%); the Heidke-skill score (percentage of the way from a reference forecast to a perfect forecast) is hence 0.35 with reference to a climatological "never-thunderstorm" forecast. When comparing to a "persistence" forecast based on thunderstorm observation in a one hour time period, the percentage of misses is better (11.4%) if the observation period is 14-15 UTC ("late persistence"), and worse (18%) if the observation period if 11-12 UTC, so before the sounding time ("early persistence").

We combined a weather type information and discriminant analysis in order to get a better adequacy of indices selection with respect to physical mechanisms at work under different regimes. We used the objective classification of 500-hPa geopotential fields designed by Benichou (1985). The two more frequent patterns for "summer" time, labeled WNW and SW after the dominant flow over France, show above, right. The results of discriminant analysis for the 15-21 UTC time period (see table on the right) show that in the

Type	WNW	SW
Frequency	53%	21%
Thunderst. frequency	21%	38%
Best index	$Adedokun_2$	$Adedokun_2$
Second index	$Telfer$	$Cape_{Doswell}$
% misses	12.7%	20%
HS-score	0.39	0.47
% misses, one index	16.2%	22.6%
Threshold, one index	0.8 °	-0.5 °

[1]The $Adedokun_2$ index is the difference between pseudo-wet-bul potential temperature i) for the ground particle, and ii) for the saturated 500 hPa particle. The $Telfer$ index is defined by an abacus which uses average dewpoint depression at 700 and 600 hPa and lapse rate between 850 and 500 hPa.

[2]The Galway index is the only one with a reversed scale: high values for low thunderstorm probability

SW regime, for which thundery and non-thundery cases are almost balanced, the HS-score of discriminant analysis is better than for the WNW regime; this may be due to the prevalence of dynamic factors in the latter, which are not taken into account in this approach. This also shows that the $Adedokun_2$ index remains the most informative in these two regimes, while the $Telfer$ index was replaced at the second rank by a Cape-like index in the SW regime.

When one uses this approach on all weather types for computing weather-type-specific discriminant equations, the overall decrease in misses is 3 %. Late persistence reaches better misses rates, and early persistence is almost as good as discriminant analysis for the WNW regime. Using the corresponding thunderstorm observations as an additional predictor in discriminant analysis surprisingly didn't improve the scores.

As regard sensitivity with respect to :

- thunderstorm intensity: when setting the thunderstorm occurrence threshold to 30 strokes, the results are worse for HS-score which falls from 0.46 to 0.31; the misses are around 9%; the most informative index are then $Cape_{max}$, $Telfer$ and $Cape_{Doswell}$;
- the number of predictors used in discriminant equations: the number of misses increases largely in the WNW regime when the discriminant equation is simplified up to a one-index rule (see the table above);
- the use of late ground observation: for the 15-21 UTC time period, the lack of such observation has almost no impact on the overall score.

Conclusion. Almost all instability indices proposed in the literature have been evaluated on a largely significant data set, for the nowcast of thunderstorms. The best ones have been identified. They have been shown to carry a limited amount of information with respect to a persistence forecast. The information added is variable depending on the time in the day and on the weather type. Critical threshold values have been proposed. The present study provides the basis for a sound use of such indices as diagnostics on LAM output, which is the subject of a companion paper (Ducrocq et al. 1997).

References

Andersson, T., M. Andersson, C. Jacobsson, and S. Nilsson (1989). Thermodynamic indices for forecasting thunderstorms in southern Sweden. *Meteor. Mag. 118*, 141–146.

Benichou, P. (1985). Automated classification of meteorological configurations over western Europe. Technical Report 18, Météo-France/SCEM. 155 pp.

Collier, C. and R. Lilley (1994). Forecasting thunderstorm initiation in north-west Europe using thermodynamic indices, satellite and radar data. *Met Apps. 1*, 75–84.

Ducrocq, V., D. Tzanos, and S.Sénési (1997). Diagnostic tools using a mesoscale NWP model for the early convection. *Submitted to Q. J. Roy. Meteor. Soc.*.

Krider, E., R. Noyle, and M. Ulman (1976). A gated, wideboard magnetic direction finder for lightning return strokes. *J. Appl. Meteor. 15*, 301–306.

MacGorman, D. and W. Taylor (1994). Positive cloud-to-ground lighning detection by a direction finder. *J. Geophys. Res. 11*, 13313–13318.

Peppler, R. and P. Lamb (1989). Tropospheric static stability and central north american growing season rainfall. *Mon. Wea. Rev. 117*, 1156–1180.

Rezacova, D. and V. Motl (1990). The use of the simple 1d steady-state convective cloud model in the decision tree for determining the probability of thunderstorm occurence. *Studio Geoph. et Geod. 34*, 147–166.

Sénési, S. and R.-M. Thepenier (1997). Instability indices and thunderstorm occurrence: Relevance in the Paris, France, surroundings. *Submitted to La Météorologie*. [In french].

Tourte, J., F. Helloco, and J. Hamelin (1988). First results obtained with the Meteorage thunderstorm monitoring system. In *8th conference on atmospheric electricity*, Uppsala, Sweden. Amer. Meteor. Soc.

VISIBILITY FORECASTING BY USE OF MESOSCALE NWP MODEL PRODUCTS

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Introduction

Visibility forecast is very important for the traffic, in particular for the air traffic the suitable accuracy of the visibility forecast is prominent. The WMO/ICAO regulations require more rigorous conditions for the forecasts year by year. The verification results of the aeronautical forecasts showed, that in case of unsuccessfull forecast, the greatest part has the bad visibility forecast. In Hungary in the last year the reason of the bad terminal air forecast (TAF) in the 70% of the cases was the not suitable visibility forecast. In our Service it was not available any numerical method, which could help the forecasters in the prediction of the visibility. So the forecasters could use only the traditional means. We asked many European countries interested in this method, but the answers was, that usually they solve this problem with the help of subjective synoptic measures. After that we decided to construct an automatical visibility forecast method which depend on output of a mesoscale numerical model.

Diagnostical method of the visibility

At first we made comprehensive statistical research using direct measures, and derived physical quantities. We tried to find connection between these elements and the visibility. The best correlation was given by the fog stability index little bit modified by us. The original index is well known in the special literature of USA. We calculated this index by using the following formula:

$$FOGSI = 2 \mid T_{sfc} - T_{850} \mid + 2 (T_{sfc} - T_{d\,scf}) + 2 W_{850},$$

where

T_{sfc}	temperature near the surface,
$T_{d\,scf}$	dew point near the surface,
T_{850}	temperature on 850 hPa level,
W_{850}	wind speed on 850 hPa level.

We can see that this index takes account the temperature gradient, (as the quantity of the stability), the impact of moisture near the surface and the mixing.

The result of statistical research

In the average autumn-winter period when in our statistical sample fog, mist, and good visibility occured, the FOGSI index had excellent correlation with detected visibility. On Figure 1. we can see the relationtion between the FOGSI index and the observed visibility.

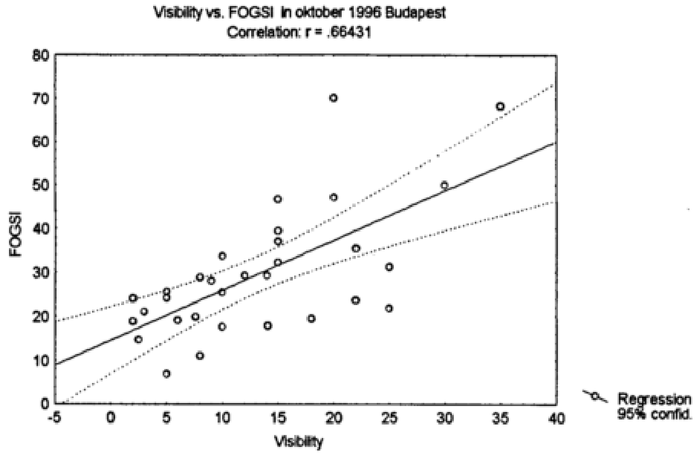

Figure 1.
Correlation between FOGSI and observed visibility.

On this figure we can see, that in given interval of FOGSI the spread of visibility values is very high and it means, that in this interval the statistical method became uncertain. So in this case we must work out a new decision procedure to separate of different visibility category. We initiated some new predictors which were not involved in terminology FOGSI and which plays great role in the forming fogy and misty situations. We intended to involve the mean relative humidity of lower air layer (surface - 925 hPa) and upper layer (825-700 hPa), and relation of these element each-other, and the windspeed near the surface too. We tried to select such type of parameters which are easy compute from both of the TEMP telegrams and from the NWP model outputs.

The result of testing our method

In the last half year (autumn and winter) we tested our diagnostical method. The method for the testing was, that we compared the computed visibility from real radiosounding data of Budapest and Szeged with the detected visibility. On the Figure 2. the observed and diagnosed visibility are compared.

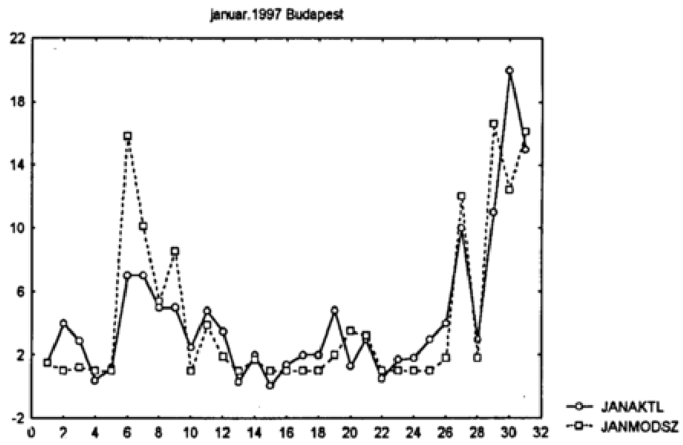

Figure 2.
Comparing detected (JANAKTL) and diagnosed (JANMODSZ) visibility for Budapest 1997 January

Well known that in case of good visibility accuracy is not so important. On the figure 3 we can see the statistical connection between elements shown on Figure 2.

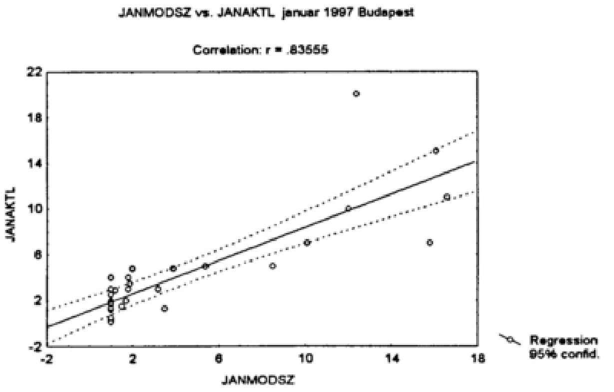

Figure 3.
Correlation between detected and diagnosed visibility for Budapest, 1997 January

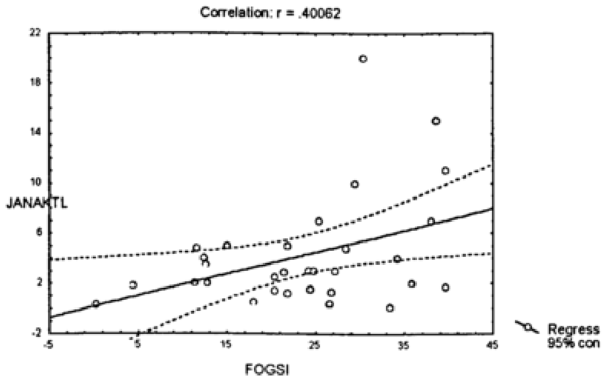

Figure 4.
Correlation between observed visibility (JANAK) and FOG (without decision procedure)

From figure 3. we can realise that we get strong correlation coefficient 0.83. It proves, that we can put this method into practice. If we had left a part of the decision procedure (not explained in this paper) the result would have been far less accurate (see figure 4).

Visibility forecast by using our method

Knowing the result of the test, we thought, that we can use it in order to support the operational synoptic work. As we mentioned one of the benefit of our method is the input parameter using information which we can easelly produced from TEMP or from NWP model. It was evident to chose the ALADIN model. On Figure 5. we can see the visibility forecast which is running experimentally every day. The time steps are on the horizontal axis.

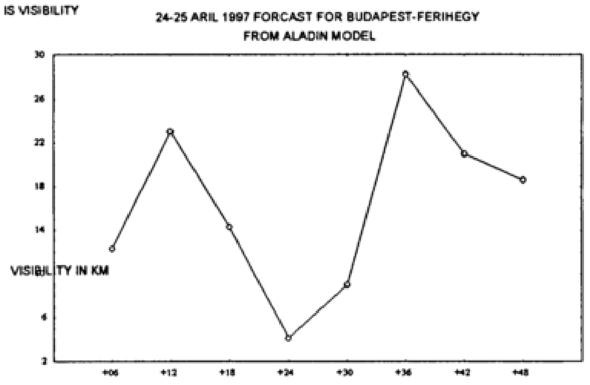

Figure 5.
Visibility forecast using ALADIN data for Budapest, April 24-25

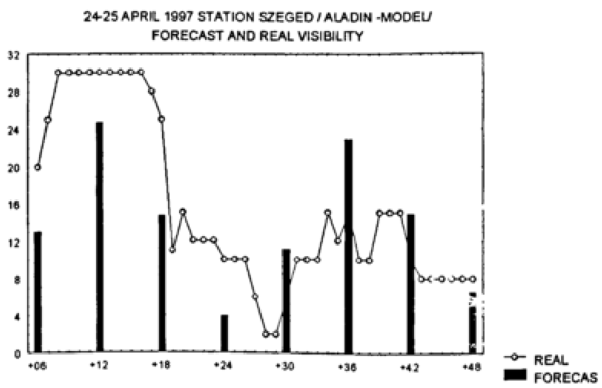

Figure 6.
Comparaison of the predicted and observed visibility.
Szeged, 24-25 April 1997

Let us see another example, +48 hours visibility forecast based on ALADIN model for station Szeged. (Fig 6.) The columns represent predicted visibility, at every time step, while continuos line is the observed visibility that time.

Today we have experimental visibility forecast for 37 stations of Hungary from where we get hourly observed visual data. From this the most important role have the visibility forecast for Budapest in order to give more successful forecast for Budapest-Ferihegy International Airport.

DECISION HELPING AND PRODUCTION APPLICATIONS ON THE SYNERGIE WORKSTATIONS AT METEO-FRANCE

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ABSTRACT

The Synergie Program is a major axis of the Météo-France strategy in terms of operational forecasting. It deals with the software development and maintenance that are required from the operational forecasting positions at the national and regional levels of the Meteo-France organisation.
The presented paper will provide with a quick review of the recent developments that have been brought to the Synergie system since the last ECAM Conference. The aspects related to meteorological production will be outlined : difference will be made between the edition and exchange of expertise data on the one hand, and the semi-automatic product derivation on the other side. Specific applications of product generation will be presented.

1. Introduction - Scope of Synergie

The SYNERGIE Program comes from a METEO-FRANCE project of Meteorological Workstation for weather monitoring and forecasting, targeted to operational weather forecasters (Bénichou et al., 1996). Synergie is now a 45 men-year development software. It has been partly put into operations in the French national and regional meterological centres in june 1994. The full implementation of the system was achieved in early 1996. Synergie has now become a central tool which helps the duty forecasters in their daily routine job as well as in specific assistances (Lefort & Peries, 1995).
The Synergie Program was launched in 1996 after the corresponding project has closed, and aims a perennial development and implementation of integrated tool for decision-helping and interactive production in the Météo-France national and regional centers.

The implementation of a new tool such as SYNERGIE in the Météo-France services must be understood as a will of homogeneization, optimization and modernization of the operational forecasting offices, in a particular political context : *Météo-France trust in the human expertise and on the added value that it can bring along the whole meteorological production process.*
In this context, the development and maintenance of a powerful and integrated tool for operational forecasting is critical for helping the forecasters facing the ever-growing amount of raw data to process and synthesize every day while enabling them to express their expertise in a numerical form.

2. Synergie as an evolutive tool for decision helping in meteorology

2.1 Any kind of data is in Synergie

A major purpose of the Synergie project was to integrate all the meteorological data into the same system in order to fasten the extraction of information and allow the forecaster to use and/or combine any type of data at any step of his work : understanding, analysis, forecasting, as well as production.

Synergie offers any classic feature one operational forecaster may expect from a meteorological workstation. The graphical environment is both intuitive and friendly, thanks to an highly graphical user-interface, a multiwindow environment, and the ability to work on two (or more) physical screens.

2.2 Standard manipulations

This involves all the features that are available in most Synergie windows :

- zoom in and zoom out cleverly (that means more data or more accuracy when zooming in) ; panning
- give the position of the cursor in lat-lon and the corresponding relevant value of the visualised data (e.g. field value for model, cloud type for satellite, rain rate or mask for radar,...)

- animate any type or combination of data (if relevant) : radar, model fields, satellite images, lightning impacts, observation plottings...
- overlay any types of data (radar, satellite, model, observations, ...) and activate any other feature (zoom, loops,...)
- save and play macrocommands : it is possible to save or to run a macro containing any number of Synergie windows and even pre-programmed loops on pictures or model fields.
- annotate any visualisation window : this facility helps forecasters in their investigation work

2.3 Visualisation features

They correspond to specific Synergie sub-applications. In each sub-application, specific features can be activated :
- models output visualisation (atmospheric and wave modeles) : visualisation, vertical cross-section of the forecast atmosphere, simulated vertical profiles,.filters...)
- observation plottings : visualisation, vertical profile from sounding stations or commercial aircrafts,...
- vertical profiles from soundings (soon profilers) : visualisation, stability index,...
- time series from terrestrial stations : combination with model output statistics and climatological values,...
- alphanumeric and graphic visualisation
- radar imagery : visualisation, interactive rainfall estimation on any time-period, thresholding,...
- lightning impact : visualisation, lightning density maps on any time-period,...
- satellite imagery: geostationary and polar orbiting images visualisation, multichannel combinations, color enhancement,...

New sub-applications are regularly developed to ingest new types of data.

2.4 Prospects in visualisation and decision helping

A major change was brought to the Synergie system in june 97, consisting in switching the data base to the Neons_Météo-France configuration. This will give the necessary basis for further developments on alarm generation. As a matter of fact, it is foreseen that as the amount of data will increase in the near future, there will be an increasing need for alarms that could be triggered from the database according to a user's configuration. Such an alarm generation could also help in some extent in the forecasters' production work.

3. Synergie as an integrated tool for interactive production

3.1 Main principle

Météo-France has now clearly split the meteorological production process into two differents steps :

a) « **expertise work** » : this stands for a work combining graphical interaction on data, data base feeding, and exhange of expertise data between forecasters : the aim of this collective work is to come with a consistent « expertise » data base containing the added value from the forecasters in all the relevants domains of forecasting. This data base can then be used at any place/moment for...

b) ...« **product derivation** » : this operation can be executed quite separately from the previous one. It needs mainly a standardized access to a « référence » data base containing all the data (raw plus expertise) that are authorized for production, and one the other side a specific tool, generally relying on an off-the-shelf commercial software for data presentation.

The Synergie Program focusses mainly on the development of specific expertise production features for the different kinds of forecasters. They enable the forecaster to work in an interactive, (geo)graphical and meteorological environment and fill meteorological databases containing the Meteo-France expertise, from which tailored products may be derived for any kind of end-users. By spring 1997 all the corresponding sub-applications are not yet available but the aim of the Synergie Program is to provide any kind of forecaster (national, regional, marine, aviation,...) with specific and adequate sub-application, under a general constraint of homogeneity and consistency in the developments as well as in the meteorological data generated by the forecasting community on the Synergie workstations.

3.2 Operational Synergie features for Expertise work

Their main interest is that they are developed in the same framework as the visualisation modules. This means that all the standard manipulations (see §2.2) are available, so that the forecasters can work both graphically and in their usual meteorological environment. This has a great advantage, particularly in the possibility of setting new methodologies for forecasting work in an interactive and integrated environment.
Up to now, several features have been developed for regional as well as for national forecasters. These features are currently in use and allow forecasters to fill a dedicated database that is then accessed by product derivation modules.

3.2.1 National level

- *Guidance* : is validated on a mixt form (graphics and text) and are sent to internal users (regional and local forecasters) for further regional or local adaptation.
- *Medias* : the database is filled with pictograms or temperatures at a european or national level and is made available for the TV Channels, who may have their own presentation software.
- *Power supply*: hourly « trains » of temperature data are validated by forecasters, with the help of MOS-type techniques and graphical interaction. The corresponding data are of high interest for power supply forecasting.

3.2.2 Regional level

- *Symposium* : this stands for a way Meteo-France has decided to express its expertise over time and space : an important database containing all relevant weather elements over hundreds of representative areas and 3-hour time steps is regularly updated. This data base is then accessed by product derivation tools that present numerous products to the end-users on dedicated supports (fax, phone, PCs, ...). The Symposium data base is a permanent result of the co-operation between local , regional and national centers. It requires a very strong forecasting organization to ensure both meteorological quality and consistency.

3.3 Features coming soon

The following new features are being implemented in operations by the end of 1997 at the Synergie sites. They mainly rely on the ability to handle « meteorological objects » in a both (geo)graphical and numerical form.

- *New guidance presentation* : a so-called PRESYG module will allow the senior forecasters in Toulouse to gather into a unique « document » a set of « objects » describing the meteorological situation at a synoptic scale : fronts, lows, high, tropopause anomalies, jetstreams, ... Interactive field modification (in two dimensions in a first step) will be offered as well, to help forecasters to produce « référence fields ».
- *Analysis module* : the analyst will be able to interact on the observation data in order to propose the best possible analysed MSLP field.
- *Marine forecasting* : a dedicated module, based on the « object » and field modification facilities, will help the forecasters issue the relevant marine products.
- *Aviation meteorology* : the low layer SIGWX charts over France will be interactively issued on the Synergie workstations by using the same « object » concept. A strong interaction between national and regional centers is planned, in order to come with a high quality product which will involve the experience of local effects from the regional forecasters.

3.4 Prospects

The Synergie Program aims to provide each forecasting position with the convenient « expertise work » features. This ambitious objective will be achieved with a strong allowance to the general forecasting organization. The resulting database will be standardized as regards to the access facilities, which will help Météo-France to develop the « Product derivation » tools in its lee side.

4. Software development strategy and hardware implementation

4.1 Software development strategy

The developments are performed according to an iterative scheme of requirements / development / validation. The new features are generally gathered and integrated into intermediate versions of the software. A major Synergie_3.0 release was under validation in june,1997 and will be made available for summer,1997 at all the Météo-France Synergie sites.
Each Synergie implementation corresponds to a tailored functional configuration of the software, in order to fit to the exact profile of the forecasting positions.

4.2 Hardware implementation

The Synergie system is based on Unix equipment and relies on a server-client architecture at any Synergie site.
By june, 1997. Météo-France runs about 20 servers and 70 stations implemented on 17 geographical sites (6 of them in the overseas territories), which corresponds to a 3 M$ investment over the 1994-1995 period. All these equipments are planned to be replaced after 1998.
Export versions of SYNERGIE can easily be derived from reference versions and implemented anywhere in the world wherever data are available in a WMO format. The commercialisation of the SYNERGIE-Export Package is performed through the SOFREAVIA[1] company on the basis of an agreement with Meteo-France. SYNERGIE is now implemented in Indonesia, Niger, Honduras, French Guyana (French Space Center), and in Marocco; it will be soon installed in Philippins, Mauritius, Lebanon...

5. Références

Bénichou P., Berthou C., Voidrot MF., 1996 : SYNERGIE as a strategic Program for Météo-France. In : *Proc. XIIth AMS Conf. on IIPS, Jan.96, Atlanta, Georgia.*
Lefort T., Péries A., 1995 :The operational use of Synergie workstation at Météo-France for analysis and forecasting. In : *Proc. 2nd European Conf. On Applications of Meteorology, Sept.95, Toulouse, France.*

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C BAND DOPPLER WEATHER RADARS AS WIND PROFILERS

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1. Introduction: It is well known that during precipitation winds are recorded by the C band Doppler weather radars of today. Less known is that these radars are sensitive enough to record echos also from clear air. Even in latitudes as high as Scandinavia such echos from the planetary boundary layer are common during summer. Clear air echos are caused by insects, birds or sharp gradients of the refractive index of the air (Vaughn 1985, Achtemeier 1991, Wilson et al 1994). During the warmer seasons generally there are enough such echos to retrieve the wind, using techniques as the VAD. VAD is an acronym for Velocity Azimuth Display, a technique to retrieve the wind profile above the radar antenna (Browning et al 1968, Persson and Andersson 1987, Andersson 1992). The technique is simple and robust but not yet used after its merits. C band Doppler weather radars are now common in Europe, and in some countries outnumber the radiosonde stations. For instance, Sweden now has 3 radiosonde stations, making soundings 4 times each *day*. The number of C band Doppler weather radars is 11, and they are scanning 4 times each *hour*. The availability of radar winds is lower than of radiosonde winds, and the radar winds do not reach as high altitudes as the radiosondes. In Sweden the radar winds generally reach heights of 6-9 km in precipitation, 1-3 km in clear air in summer. As said above, the resolution of the radar winds is much superiour to the radiosonde winds in space as well as in time.

The most conspicous error source, as for VHF and UHF radars, is birds. Mass bird concentrations occur during migration or in the vicinity of breeding colonies, nocturnal roosts, premigratory staging areas or concentrated feeding areas (Vaughn, 1985). Common in Sweden is migration during spring and autumn nights. The SMHI VAD routine (Andersson, 1992) now installed at all Swedish Doppler weather radars, has an algorithm to identify such bird echos.

Winds from operative C band radars form an hitherto very little used, or neglected, data source. It may be that the possible users are uncertain about their quality. There are, however, ample reasons that they are of a very good quality, and the reasons for doubts may be that the users associate to the difficulties with radar rain rate estimates. The relation between the strength of the radar return signal (the reflectivity) and the rain rate is very complex, and there is no universal relation between these parameters. This is not only due to meteorological reasons, technically the calibration of weather radars is complex, and there are no internationally agreed procedures. The wind estimates are given by a straight-forward application of the Doppler principle, which gives an unambiguous answer (within the unambiguous velocity range). Since the doppler principle only gives the wind in the radial direction, these radial winds must in some way be converted to real (2 or 3 dimensional) winds. The rest of this paper will verify winds retrieved by the VAD routine of SMHI (Andersson 1992) through comparing them with simultaneous radiosonde winds from a nearby site.

2. Verification of the VAD routine of SMH

The data used is about seven months of RAWINDs from Landwetter (57.67 ° N, 12.30 ° E, 155 m above M.S.L) at 00, 06, 12 and 18 UTC and simultaneous VADs from Jonsered (57.72 ° N, 12.17 ° E, 164 m above M.S.L). With 'simultaneous' is meant that the radiosonde was generally released at HH-1:40 and the VAD begun at HH-1:47 or HH:02. Winds were extracted from five so called 'main isobaric surfaces', 925, 850, 700, 500 and 400 hPa, corresponding to heights above M.S.L. of about 750, 1450, 3000, 5600 and 7200 m. An Ericsson C band weather radar was used for the VADs, and Vaisala radiosondes were used for the RAWINDs. The sondes were tracked by the Loran C or Omega systems. All the available data was used, except of 4 VADs where the winds were obviously caused by migrating birds. Table 1 shows that the largest discrepancies occur at the lowest level, 925 hPa. There the VADs give 0.7 m/s higher wind speeds, a difference that decreases with height. Interesting is that analyses by our limited area model, HIRLAM, at 850 hPa give about 0.4 m/s lower wind speeds than the radiosondes (Ericsson et al 1997). Comparisons between HIRLAM and VAD winds at 850 hPa (Andersson 1994, 1997) show that the VAD wind speeds are about 1.4 m/s above the HIRLAM ones. It is difficult to find any reason that the VAD should overestimate the wind speed at the lowest levels when it evidently does not at higher levels. Table 1 also shows that the average wind directions are very similar, though with a large scatter in the two lowest levels, Table 2 (*absdev* and *rms*). Large direction differences mainly occur at low wind speeds. Excluding speeds below 10 m/s decreases for instance the *absdev* at 925 hPa from 18 ° to 9 °.

Table 1. Average wind direction and speed for the pressure surfaces 925, 850, 700, 500 and 400 hPa according to VAD from Jonsered and RAWIND from Landwetter. Regard to the fact that wind directions may be just below 360 ° and just above 0° has been paid in this way: If one direction is 355 ° and the other 3° has 360 been added to the latter. Four cases with migrating birds are excluded. Period 9 Dec. 1994 - 14 Feb. 1995 and 28 Jun. - 30 Nov. 1995.

	925 hPa		*850 hPa*		*700 hPa*		*500 hPa*		*400 hPa*	
	degrees	*m/s*	*degrees*	*m/s*	*degrees*	*m/s*	*degrees*	*m/s*	*degrees*	*m/s*
VAD	*212*	*10.7*	*221*	*11.1*	*234*	*13.3*	*225*	*18.3*	*224*	*21.0*
RAWIND	*211*	*10.0*	*220*	*10.7*	*234*	*13.5*	*226*	*18.5*	*225*	*21.6*
no of pairs	*423*		*358*		*173*		*115*		*87*	

Table 2. Scatter between winds according to VAD from Jonsered and RAWIND from Landwetter
absdev = average of absolute differences *rms = root mean square error*
corr = coefficient of correlation.
Period 9 Dec. 1994 - 14 Feb. 1995 and 28 Jun. - 30 Nov. 1995.

	925 hPa		*850 hPa*		*700 hPa*		*500 hPa*		*400 hPa*	
	degrees	*m/s*	*degrees*	*m/s*	*degrees*	*m/s*	*degrees*	*m/s*	*degrees*	*m/s*
absdev	*18*	*1.9*	*15*	*1.6*	*13*	*1.8*	*7*	*1.8*	*5*	*1.7*
rms	*30*	*2.6*	*28*	*2.2*	*29*	*2.5*	*11*	*2.5*	*7*	*2.6*
corr	*0.95*	*0.90*	*0.95*	*0.94*	*0.94*	*0.94*	*0.99*	*0.96*	*0.99*	*0.97*
no of pairs	*423*		*358*		*173*		*115*		*87*	

It is interesting to note that the absolute differences between VAD and RAWIND wind speeds are about the same as between RAWIND and winds analysed by HIRLAM. For instance at 500 hPa the absolute difference betwen the latter two was just below 2.0 m/s (Ericsson et al 1997), cf *absdev* in Table 2. It must also be noted that after these comparisons some large, hitherto unexplained, errors in Swedish radiosonde winds have been detected. For more comprehensive descriptions of comparisons between RAWIND and VAD as well as for discussions of RAWIND errors and representativeness, the reader is referred to the reference list (Andersson 1994, 1995 and 1997, Andersson and Bandalo 1994, Brown 1994. Davis et al 1995, Kitchen 1988, Yagi et al 1996).

3. Availability of VAD winds

Decisive for the possible use of VAD winds in the weather service is their availability and the heights they reach. Table 3 shows their availability at different pressure surfaces. The RAWIND has served as base for the 'availability'. If, for a certain level, out of 100 RAWINDs a simultaneous VAD wind has been available for 93 cases, the availability is 93 %. 'Clear' is defined as 'non-precipitation', i. e. as far as one can judge from synoptic maps and radar reflectivity pictures there has been no precipitation or virga within the VAD area, a circle with a radius of 30 km, centered at the radar antenna.

4. Conclusions

Winds retrieved by our VAD routine seem compatible to radiosonde winds. During the warmer seasons ordinary C band Doppler weather radars nearly always record clear air echos in the planetary boundary layer even in latitudes as high as Scandinavia. There are generally enough echos to retrieve winds up to 1-3 km height with our VAD routine. In precipitation generally our VAD gives winds up to 6-9 km height. In some countries, for instance Sweden, the Doppler weather radars outnumber the radiosonde stations, and thus give a higher space resolution. Since the time resolution of radars is also much higher than of radiosondes, the VAD winds should form a valuable input to numerical prediction models, as they already do in the US. VAD and radiosonde winds could also be used to check each other.

Table 3. Availability of VAD winds at Jonsered. ' Whole' is 9 Dec. 1994 - 14 Feb. 1995 and 28 Jun. - 30 Nov. 1995. 'Summer' is 28 Jun. - 30 Sep. 1995. See text for definitions.

	PRESSURE LEVEL, hPa				
PERIOD AND WEATHER	*925*	*850*	*700*	*500*	*400*
Whole, Clear and not Clear, 00-24 UTC	*0.83*	*0.64*	*0.31*	*0.20*	*0.15*
Summer, not Clear, 00-24 UTC	*0.92*	*0.89*	*0.61*	*0.44*	*0.35*
Summer, Clear, 00-24 UTC	*0.94*	*0.76*	*0.15*		
Summer, Clear, 00 UTC	*0.98*	*0.72*	*0.13*		
Summer, Clear, 06 UTC	*0.83*	*0.59*	*0.16*		
Summer, Clear, 12 UTC	*0.94*	*0.98*	*0.30*		
Summer, Clear, 18 UTC	*1.00*	*0.74*	*0.06*		

References:

Achtemeier, G.L., 1991: The use of insects as tracers for "Clear-Air" boundary layer studies by Doppler radar. *J. Atmos. Oceanic Technol.*, **8**, 746-765.

Andersson, T., 1992: A method for estimating the wind profile and vertical speed of targets from a single doppler radar. *Instruments and Observing Methods*, Report No. 49, WMO/TD, No. 462, p. 380-386.

Andersson, T., 1994: VAD winds at 850 and 700 hPa compared to forecasted winds from the HIRLAM. *COST75*, WD/60/B, 4 p.

Andersson, T. and S. Bandalo, 1994: VAD winds, their accuracy and use. *EUCO-COST75*, 75/5/94, 19 p.

Andersson, T., 1995: Test of a method for recovering winds from a single Doppler weather radar. *COST75, Weather radar systems*, Ed. C.G. Collier, International seminar, Brussels, Belgium, 20-23 Sep. 1994, EUR 16013, pp. 333-344.

Andersson, T., 1997: VAD wind profiles from C band Doppler weather radars. *COST75*, 75/WD/109.

Brown, C., 1994: Accuracy of wind measurements from an SPS Doppler weather radar. *COST75*, WD/71B.

Browning, K.H. and G.H. Monk, 1968: The determination of the kinematic properties of a wind field using Doppler radar. *J. Appl. Meteor.*, **7**, 105-113.

Davis, J.L., R.R. Lee and J.L. Ingram, 1995: Comparing rawinsonde and WSR-88D wind profiles. *Preprints, 27th Conf. Radar Meteor.*, Vail, Colorado, 409-411.

Ericsson, G., K-I. Ivarsson and O. Åkesson, 1997: Verifikationsbulletin för året 1996. *Sveriges Meteorologiska och Hydrologiska Institut*, Internal serie.

Kitchen, M., 1988: Representativeness errors for radiosonde observations. *Quart. J. Roy. Meteor. Soc.*, **115**, 673-700.

Persson, P.O.G. and T. Andersson, 1987: Automatic wind field interpretation of Doppler radial wind components. *SMHI, PROMIS Reports*, No 6, 72 p.

Vaughn, C., 1985: Birds and Insects as Radar Targets. A Review. *Proc. IEEE*, **73**, 205-227.

Wilson, J.W., T.M. Weckwerth, J. Vivekanandan, R.M. Wakimoto and R.W. Russell, 1994: Boundary Layer Clear-Air Radar Echoes: Origin of Echoes and Accuracy of Derived Winds. *J. Atm. Ocean. Techn.*, **11**, 1184-1206.

Yagi, S., A. Mita and N. Inoue, 1996: WMO International Radiosonde Comparison, Phase 4. *Instruments and Observing Methods*, Report No. 59, WMO/TD, No. 742, 130 p.

HIRLAM 1D; a one-dimensional version of the HIRLAM model

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1. Introduction

A one-dimensional version of the HIRLAM model has been developed. It has been designed to produce detailed forecasts of all weather elements in an operational environment on a short timescale (0-12 hours) . Originally the model was designed to assist the forecaster in the production of terminal area forecasts (TAFs). But, since there also is a need for area-coverage short range forecasts SMHI have started to develop a gridpoint version of the model. The gridpoint version will cover the time gap, that normally exists in gridded information, between analysis and normal NWP-output.

2. Model assumptions

The general idea with this model approach is as follows:

- Use a higher vertical resolution than that of the operational 3-D model.
- Run the 1-D model forced by advective processes from the 3-D model.
- Estimate an initial profile at each forecast point using both information from the 3-D model and from local observations.
- Utilise a local physiography

The main advantage of this approach is that it is possible to run a new forecast very frequently using the local observations without having to do a complete new numerical analysis. One limitation of the approach is that there is no small scale dynamics present. It is not possible to describe circulation's that the 3-D model can't resolve., e.g. seabreeze. The physics of the 1-D model is the same as in the operational 3-D HIRLAM at SMHI (Kållberg, 1990; Gustafsson 1993). Since the same computer code is used in both models, the 1-D version can be utilised as a development tool for the HIRLAM physics. The original HIRLAM vertical diffusion scheme is replaced by a non-local version in the 1-D model. Cloud water mixing ratio is a prognostic variable in both models. For the advective processes the complete 3-D model state for the area of interest is stored with a time resolution of one hour. This information is then used to calculate what is called dynamical tendencies at each forecast point. These tendencies are fed into the 1-D model as a large scale forcing at each timestep.

The initial profile for a model run is taken from the 3-D model state. It is then interpolated to the 1-D model vertical resolution. This profile is then modified according to the observation (SYNOP or METAR) at the forecast point. Observations of temperature and humidity at the 2-meter level, wind at 10 m, cloud amount and cloud base are used. There are different algorithms depending on the cloud observation. E.g. if a broken cloud cover is observed and the clouds are in the boundary layer, the algorithm works as follows: Estimate a local lapse rate below the clouds using the observed 10-meter wind speed as input. It is assumed that high wind speeds corresponds to a more mixed boundary layer. Construct a temperature profile below the clouds using the observed 2-meter temperature and the estimated lapse rate. The specific humidity is changed according to a linear interpolation between the observed value at 2 meter and the value at the cloudbase where the humidity is assumed to be saturated. The top of the clouds is estimated to be at the top of the boundary layer. Surface wetness is an important parameter for short range forecasting. This parameter is hard to analyse with the present observation systems. One way to get a better estimation is to run the model a few timesteps with different values of surface wetness and compare the forecasts of dewpoint and cloudbase with observations of the same parameters. The surface wetness that gives the best agreement is then used as starting value in the forecast.

3. Applications

3.1 Airports

The 1-D model has been used for short-range forecasts at all Swedish civilian airports for some time now. The METARs at the airports are utilised to contract initial profiles for the model. "Airport" values of physiographic parameters such as roughness, albedo and fraction of land are used in the model runs. The model is run every hour as soon as the observation arrives. Model output is used to produce automatic TAFs (Terminal Area Forecasts). The model itself produces wind and cloud forecasts but for visibility and weather there has to be some algorithms to interpret the model data. It is possible to distinguish between "convective" and "stratiform" clouds and weather since that distinction is done within the model itself. The interpreted data is then put in to a program that has been developed by the Finnish Meteorological Institute (FMI) and out comes a TAF-coded forecast. The automatic TAFs has been compared to the manual TAFs for a test period and on the average the automatic version score slightly higher than the manual, but for difficult weather situations the forecasters seems to do better than the model.

3.2 Gridpoints

The 3-dimensional NWP models doesn't produce useful products on the shortest timescale (0-6 h). There are spinup problems and it usually takes quite a while after observation time until the output is available for the forecaster. To fill this gap SMHI has started to develop a version of the 1-D model that will be run on a grid of about 10-20 km over Sweden. The same technique as for the airports will be applied, high vertical resolution and forcing from the 3-D model. A mesoscale analysis system (Mesan) will be used to make a better estimation of the initial profile instead of observations. Mesan produces detailed analysis of temperature and humidity at the 2-meter level, wind at 10 meter, visibility, precipitation, cloud amount, cloud base and cloud top. So essentially the same information as in an observation is available on a grid and the same technique as above can be applied to construct an initial profile that has taken the latest information into account. Here the original HIRLAM physiography will be utilised. The cloud top information will be very useful in situations with large areas of fog and stratus since the thickness of fog/stratus is a critical parameter to know for successful fog/stratus forecasting. In that sense Mesan will give better information than METAR. Some preliminary tests shows that this model is able to produce useful forecasts on the shortest timescale.

4. Summary

A one-dimensional version of the HIRLAM model has been used for some time now within the Swedish Meteorological and Hydrological Institute. It has proven to be a useful tool in short-range forecasting of all weather parameters in many different weather situations. This model will be an important part of the new, more automatic production system that is being built right now (Lindh, 1997). As long as the NWP-models are unable to utilise detailed cloud and precipitation information from different observation systems there is a place in the weather services for this kind of models.

References:

Gollvik, S., E. Olsson, (1995). A one-dimensional model for detailed short range forecasting. Meteorol. Appl. 2, pp. 209-216.

Gustafsson, N. (ed.) (1993). HIRLAM2 Final Report. Technical Report No. 9

Kållberg, P.(ed.) (1990). HIRLAM Forecast Model Level 1. Documentation manual.

Häggmark, L., K. I. Ivarsson, and P. O. Olofsson, (1997). Mesan, Mesoskalig Analys. SMHI RMK Nr 75 (in Swedish).

Lindh, O., S. Nilsson, (1997). RiPP; a Development Project for Increased Efficiency and Automatization of the Production Process in Sweden. 3rd European Conference on Applications of Meteorology, Lindau, Germany. (in this preprint volume).

Development of an Automated Site-Specific Forecast Model

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ABSTRACT

The UK Met. Office has run mesoscale models for regular forecasting for about a decade. The current operational model now provides input to automated and semi-automated products such as the Open Road system. However, projected improvements in computer power suggest that truly local or site-specific forecasts will not be practicable for at least another decade, particularly where problems such as overnight frost and fog, which may be strongly controlled by local surface forcing, are considered. As an alternative, a site-specific model is being developed based upon a 1D model directly coupled to the operational mesoscale model. This model is constructed from the same physical parametrizations as the UKMO Unified Model, with improvements to the treatment of the surface and soil system. It uses improved vertical resolution and a surface specification more appropriate to specific sites. A first version of the model has been running routinely since October 1996, and these changes alone have already produced a significant improvement in site-specific forecast skill over the mesoscale model. Further enhancements to take more account of local forcing are currently being developed. This paper briefly describes the model and its performance, primarily for temperature forecasts over the 0-18 time frame.

Introduction

The UK Met. Office has run an operational mesoscale models for regular forecasting for about a decade: the current horizontal resolution of this is approximately 16.7 km, and is likely to improve in the near future. This is fairly typical of current operational systems around the world which are run at 10-20 km resolution. Horizontal resolution of 2-3 km is currently feasible over smaller areas and improvements in computer power should make operational models possible with this resolution over areas around 1500x1500 km within a few years. However, even this resolution is insufficient to resolve surface inhomogeneities that can lead to significant impact on near-surface forecast variables such as temperature and visibility. Alternative methods of relating mesoscale average quantities to local or site-specific conditions are therefore required, and will probably still be required for at least the next decade. Statistical methods cannot easily provide a non-linear response to the larger scale forecast. A good example might be the formation of fog during the night, the subsequent impact on surface heating in the morning, and so the impact on subsequent maximum temperatures. In this case, some degree of physical modelling has to be built into the system. Human forecasters can take these interactions into account, but even where this can be done quantitatively, it is not always practicable to do so for a large number of sites, when an automated system is required.

A physical model-based site-specific forecast model (SSFM) is currently under development in the UK Met. Office (UKMO) based upon a 1D model containing essentially the same physics as the UKMO operational mesoscale model (i.e. the UKMO Unified Model (UM)) with some improvements, particularly to the surface exchange. This includes a soil temperature and hydrology scheme, surface exchange and boundary layer mixing, cloud formation and layer and convective cloud formation, along with a full radiation scheme. It is driven by output from the mesoscale model.

Description

The approach is very similar to that adopted by Gollvik and Olsson (1995) using HIRLAM physics. The model is run at higher resolution than the driving model within the boundary layer (53 layers below 2.2 km), primarily to improve the resolution of stable layers, and uses surface characteristics more relevant to the actual fetch at the site in question. In this the philosophy differs slightly from Gollvik and Olsson in that within our model we aim to improve site-specific skill by concentrating on a specifying a site-specific fetch, which will depend on detailed, directionally dependent surface characteristics and, to a smaller extent, taking account of small scale orography. A first version has, however, been implemented using fixed surface characteristics. These are based on a combination of 10 km resolution land-use data a knowledge of the sites being studied and so are regarded as more representative than the surface data in the driving model, but at this stage are an interim measure.

This version incorporated a much more sophisticated surface model, which includes a description of plant physiology that models the behaviour of stomatal resistance as a function of plant type, soil moisture, solar radiation, air temperature and humidity and CO_2 availability, together with a multi-layer soil hydrology scheme including the effects of soil moisture freezing. The scheme was modified, to take into account of the impact of the effect of decoupling of the air from the soil as a result of intervening vegetation. This scheme is described by Best, 1997, but essentially assumes that normal surface exchange occurs between the air and vegetation but that the latter is coupled to the soil only by long-wave radiation. The scheme is similar to that proposed by Deardorff, 1978. This allows more dramatic cooling over grass, for example, compared with bare soil surfaces on radiation nights.

The model has been run routinely for 15 UK sites since 14 October 1996. 14 of these sites are standard synoptic observing stations while the 15th is the Met. Offices boundary layer Research Unit at Cardington, Bedfordshire (52.11N, 0.43W). Here, along with surface layer temperature, humidity and wind, surface fluxes of heat, moisture and radiation plus soil temperatures at 4 depths were measured. The model was run four times a day, to coincide with runs of the operational mesoscale model, and forecasts generated out to T+18.

Over the period 14 October 1996 to 13 January 1997, various configurations were run to gauge which changes to the model had beneficial impact. One of these implemented exactly the same resolution, physics and surface characteristics as in the mesoscale model in order to demonstrate that our forcing strategy produces results which are acceptably close to the mesoscale results when the formulation is the same. This was initialized with data from the mesoscale analysis interpolated to the site. The same profile, interpolated, was used to initialize configurations of the high resolution version. In addition, configurations were run initialized from the previous model forecast at T+6, in order to retain soil temperature and moisture information. In this case, versions were run with high resolution (9 levels) in the soil.

The results from this trial demonstrated clearly the importance of local surface exchange on forecast results. As an example, forecast performance for overnight air frost from the 12Z run is summarized in the following table. Any observation of air temperature (at screen height) below freezing is between 18Z and 06Z is defined as 'frost' (obs.), with an equivalent for the forecast. The table compares the SSFM with and without the radiative vegetation canopy with the equivalent mesoscale forecasts. The period included a very cold spell, with daily maximum temperatures barely exceeding zero, so the general skill is high. However, the SSFM with canopy achieves a modest improvement in skill (measured by a Hanssen and Kuiper score). Without the 'vegetation canopy' the performance is substantially worse.

	Mesoscale			SSFM with canopy			SSFM without canopy		
	Obs.	Not Obs.	Skill Score	Obs.	Not Obs.	Skill Score	Obs.	Not Obs.	Skill Score
Forecast	41	3	78 %	43	3	82 %	36	2	71 %
Not Forecast	6	33		4	33		11	34	

Although the number of non-frost events is the same for the mesoscale model and SSFMwith canopy, the actual events were not all the same, since the SSFM does not always predict lower temperatures. The general effect of including the vegetation canopy is to reduce the surface temperature on radiation nights and thereby, usually, reduce the screen temperature. This effect is illustrated in Figure 1, Figure 4, which shows forecast temperatures from 12Z, 15/04/97 to 06Z 16/04/97 at Cardington. The initial forcing model, on this occasion, was about 1 degree too warm throughout, and the wind slightly too strong during the later part of the forecast. In spite of these biases, the results illustrate well the significant impact of the vegetation canopy. However, during the end of December/ early January period the long term effect of reducing soil cooling became important. Soil temperatures near the surface were monitored beneath the grass surface. Measurements at a depth of 0.1 m are

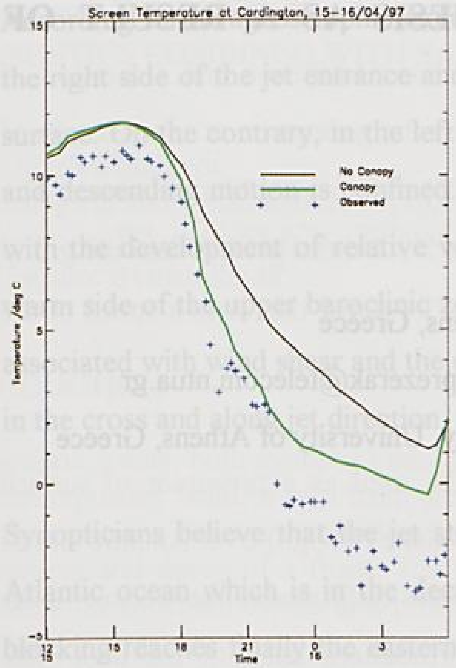

Figure 1 Model forecast screen temperature from 12Z, 15/04/97, at Cardington compared with observations.

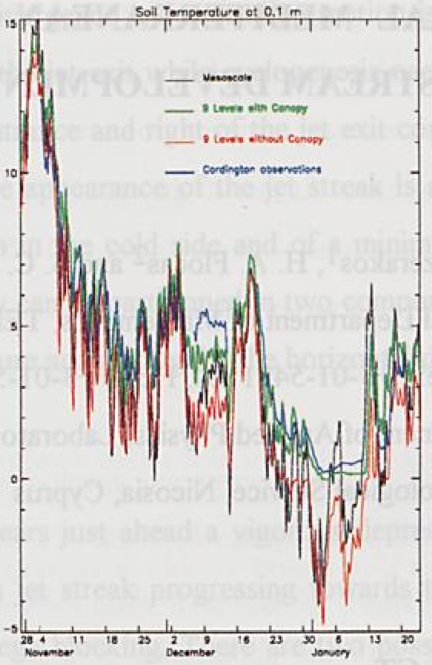

Figure 2 Observed and forecast 0.1 m soil temperatures at Cardington, Oct 1996-Jan 1997. Forecasts are from mesoscale analyses and continuous SSFM forecasts.

shown in Figure 2. These are compared with soil temperatures from the mesoscale model (interpolated logarithmically to this depth) and from the SSFM. The impact of the canopy during the late December/January period is clear. It served to raise forecast soil temperatures several degrees to slightly above freezing, though soil closer to the surface did freeze, the effect of which is taken into account in MOSES. The impact of this on forecasts is illustrated in Figure 3. In contrast to the usual behaviour, the (relatively) warm soil resulting from the canopy serves to provide sufficient upward heat flux to stop the screen temperature dropping overnight. This effect lead to a number of forecasts where frost was correctly forecast not to occur, contradicting the larger scale model guidance, and illustrates the importance of the long term temperature history at a site and its interaction with surface conditions.

The next version of the SSFM is currently under construction and will implement a site-specific directionally and stability dependent fetch specification which, it is hoped, will further improve the performance.

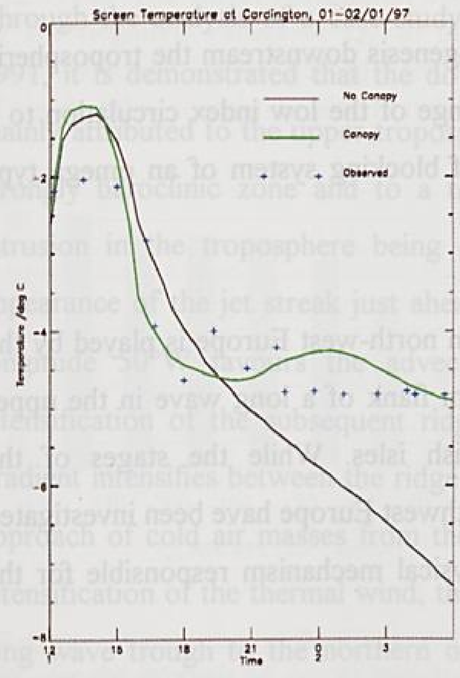

Figure 3 Model forecast screen temperature from 12Z, 01/01/97, at Cardington compared with observations.

References

Best, M. J., 1997, A Model To Predict Surface Temperatures, Boundary Layer Met., Submitted.

Deardorff, J.W., 1978, Efficient Prediction of Ground Surface Temperature and Moisture, With Inclusion of a Layer of Vegetation, J. Geophys. Res., **83**, 1889-1903

Gollvik, S. and Olsson, E., 1995, A one dimensional interpretation model for detailed short range forecasting. Metworol. Appl. 2, pp 209-216.

CENTRAL MEDITERRANEAN CYCLOGENESIS AS A RESULT OF DOWNSTREAM DEVELOPMENT

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ABSTRACT

Downstream development is the intensification of a trough of a synoptic or larger scale wave in the free upper troposphere that causes the intensification of the another trough to its downstream side or the development of a new trough after the intensification of a preceeding ridge. The downstream development occurs primarily during the change of the high index circulation to low and in some cases after the predominance of the low index circulation.

The main objective of this study is to investigate the cyclogenesis downstream the tropospheric air flow in the region of north-west Europe, after the change of the low index circulation to a high index trpospheric circulation and the development of blocking system of an omega type blocking.

The most important role in the downstream development in north-west Europe is played by the appearance of a jet streak at the northern and northeastern flank of a long wave in the upper troposphere of omega blocking centred over the British isles. While the stages of the development after the appearance of the jet streak over northwest Europe have been investigated both from theoretical and synoptic point of view, the physical mechanism responsible for the appearance of the jet streak has not yet investigated.

According to the ageostrophic circulation pattern, divergence and ascending motion is found in the right side of the jet entrance and the left side of the jet exit while cyclogenesis occurs in the surface. On the contrary, in the left side of the jet entrance and right of the jet exit convergence and descending motion is confined. Furthermore, the appearance of the jet streak is associated with the development of relative vorticity maximum in the cold side and of a minimum in the warm side of the upper baroclinic zone. The vorticity can be partitioned in two components, one associated with wind shear and the other with curvature accounting for the horizontal divergence in the cross and along jet direction, respectively.

Synopticians believe that the jet streak initially appears just ahead a vigorous depression over Atlantic ocean which is in the decaying stage. This jet streak progressing towards the omega blocking reaches finally the eastern flank of the omega blocking. There are two possibilities to occur depending on the characteristics of the subsequent trough: i) if the trough is diffluent with its axis orientated NW-SE, the trough will intensify or ii) if the trough does not show these characteristics or does not exist at all, a part of the vorticity associated with windshear is converted to vorticity associated with curvature leading to the formation of a smaller scale wave at the flanks of the large scale high. This wave moves very fast southeastwards, intensifies and causes surface cyclogenesis under favourable low level conditions.

Through the analysis of a case-study that occurred in the time period from 3 to 9 December 1991, it is demonstrated that the downstream development over northwest Europe could be mainly attributed to the upper tropospheric frontogenesis with the form of a jet streak within a strongly baroclinic zone and to a tropopause folding associated with cold stratospheric air intrusion in the troposphere being characterised by high values of potential vorticity. The appearance of the jet streak just ahead of a developed trough centred in the Atlantic ocean at longitude 50°W favours the advection of warm air masses northwards, resulting in the intensification of the subsequent ridge and its expansion northwards. Therefore, the thermal gradient intensifies between the ridge in the south and a second trough further north due to the approach of cold air masses from the north and warm air masses from the south. Due to the intensification of the thermal wind, the jet streak moves from the western inflection point of the long wave trough to the northern or northeastern flank of the ridge. This jet streak can be considered as the concentration of the eddy kinetic energy which has diffused and dispersed by the Atlantic depression after the stage of its maximum development. Following this physical mechanism, the ageostrophic convergence of geopotential fluxes (diffusion and dispersion of eddy kinetic energy) transfers downstream and further triggers the generation or rejuvenation of a new disturbance further to the east (here in a distance of 70°) over central Mediterranean. The energy is transferred with a velocity of 17.5° per day which is 2-3.5 times greater than the group velocity of the atmospheric waves (5°-10° per day). It should be noted that such a speed of the eddy kinetic energy transfer is not completely understandable.

Two stages of the downstream development process can be used as a precursor of surface cyclogenesis: a) strong development of a tropospheric disturbance (trough) over Atlantic and b) intensification of a long wave (ridge) in the region of British Isles or further to the west or to the east along with the appearance of a jet streak at the northeastern flank of the high. The cyclogenesis over central Mediterranean is likely to occur two days later under favourable low level conditions.

FORECASTING FRONTOGENESIS AND FRONTOLYSIS BY MEANS OF Q-VECTOR DIAGNOSTICS COMBINED WITH SATELLITE IMAGES

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INTRODUCTION

Atmospheric fronts, both synoptic- and meso-scale ones, play a major role in meteorology. Some of the most important features of a front are frontogenetic structure, the cross-frontal circulation and the along frontal jet. The terms frontogenesis and frontolysis, respectively, designate the dynamical development and decay of a front. The process of frontogenesis is closely linked to a cross-frontal circulation due to which clouds and precipitation along the front form. The vertical component of this circulation is proportional to the divergence of the Q-vector (Hoskins et al., 1978). On the other hand, the normal component of the Q-vector (Q_n) stands for frontogenetic or frontolytic processes in the geostrophic wind field (Kurz, 1990).

STATISTICAL ANALYSIS

Having noticed that there is correspondence between Q_n values and grey shade values in satellite imagery, it was of interest to find out whether a general statistical correlation between the values of Q_n and the pixel values in the satellite image exists. Therefore, a statistical analysis has been done on a six-month data set. The values of Q_n in three different isobaric levels, 850, 700 and 500 hPa, from the ECMWF model analysis fields were compared with pixel values in METEOSAT infra-red images at 00 and 12 UTC. The mean correlation coefficients are negative in all investigated levels so that a tendency for negative values of Q_n to be associated with cold cloud tops is signaled. The best correlation was found for the 850 hPa level, but the correlation coefficient is still quite low ($r \sim 0.3$) when all six months, containing also non-frontal cloudiness, are taken together (Strelec et al., 1997).

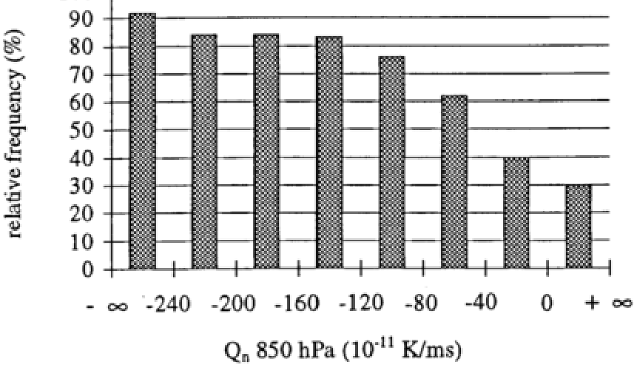

Fig. 1: Relative frequencies of IR pixels with values above 156, for the intervals of Q_n as indicated on the abscissa, for the whole 6 months data set

Relative frequencies show that for $Q_n<-40\cdot10^{-11}$ K/ms at 850 hPa more than 60% of pixels have values higher than 156, for $Q_n<-80\cdot10^{-11}$ K/ms more than 75% and for $Q_n<-120\cdot10^{-11}$ K/ms more than 80% (Fig.1). (The IR value of 156 was taken as a threshold value for clouds.) But for a pixel value greater than 156, the corresponding Q_n value is by no means necessarily negative. There is still an amount of 23% of all pixels with values above this threshold having at the same time a corresponding positive Q_n value at 850 hPa.

A better correlation could be expected when only frontal cases are analyzed, therefore 14 satellite images in February 1995, containing the cloudiness of the cold fronts, were evaluated. Correspondence between Q_n and IR indeed becomes better for frontal cases (Fig. 2).

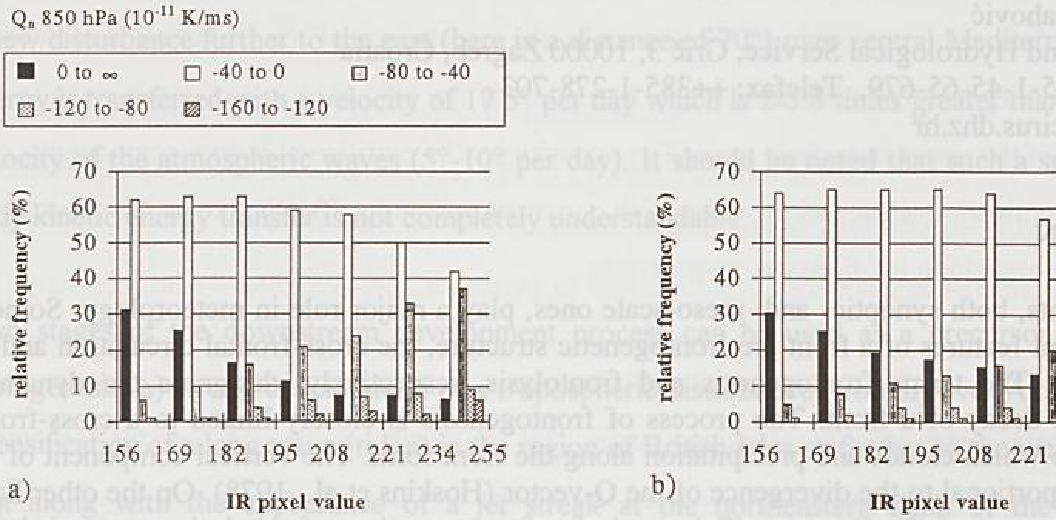

Fig. 2: Histogram analysis of values of Q_n (850 hPa) for intervals of IR pixel values as indicated on abscissa, a) for 14 selected cases and b) for the whole month of February 1995. See legend for the definition of classes of Q_n .

For IR pixel values greater than 156, the relative frequency of points with $Q_n > -40 \cdot 10^{-11}$ K/ms is smaller in the selected frontal cases than for the whole month of February, while the percentage of points with $Q_n < -80 \cdot 10^{-11}$ K/ms is larger for the frontal cases.

APPLICATION IN FORECASTING

A possibility of using the combination of Q_n fields and infra-red satellite images in forecasting frontal development or decay is shown by means of an example. It deals with the development of frontal cloudiness caused by strong frontogenesis (Fig.3).

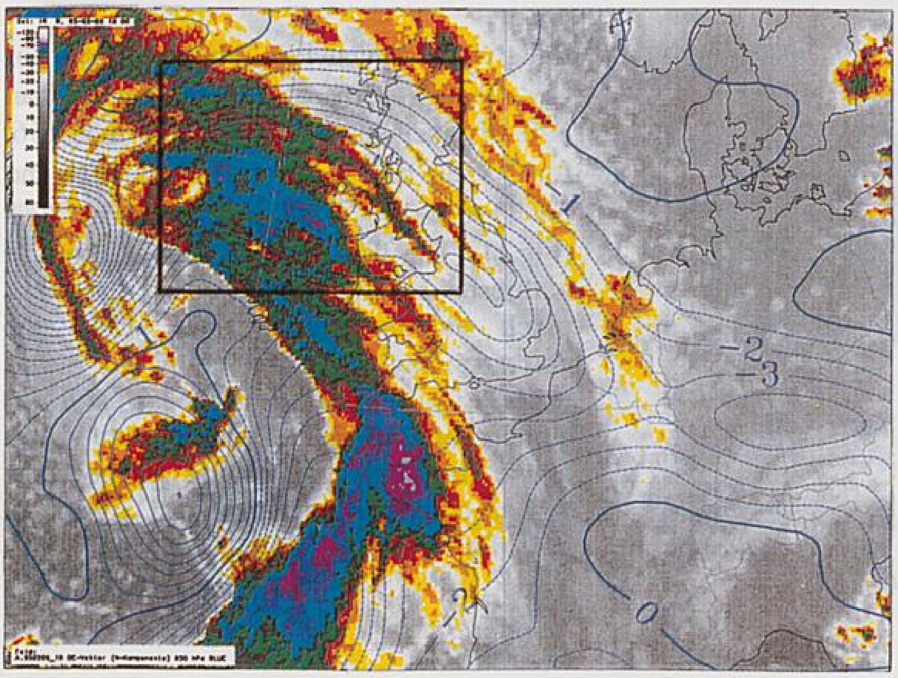

Fig. 3a: METEOSAT IR image on 09 February 1995, 18 UTC, combined with the isolines of Q_n. A region where frontogenesis is expected is marked by a rectangle.

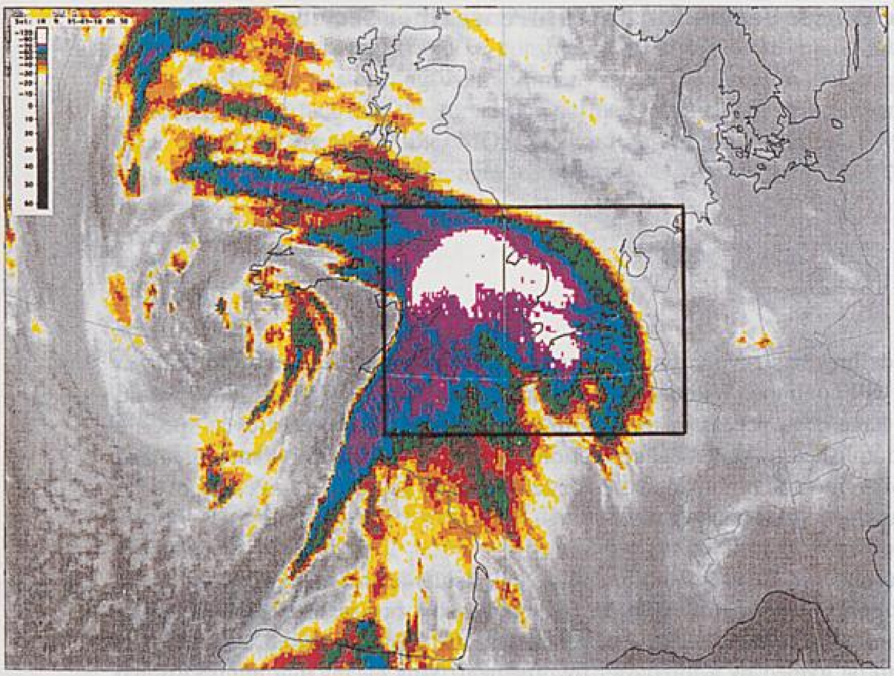

Fig. 3b: METEOSAT IR image on 10 February 1995, 00 UTC showing that the clouds have rapidly developed in the marked region

An occluded frontal system lies over the British Isles and the Bay of Biscay. The minimal values of Q_n are situated in the region where the cloud band of the warm front should be expected (within the rectangle drawn in Fig.3a), but the pixel values are low. During the next 6 hours, remarkably strong development occurs in the region where Q_n had its minimum (Fig.3b).

CONCLUSION

The best correlation between Q_n and IR pixel values is found for the 850 hPa level within frontal zones, where for IR pixel values above 156, the probability that the corresponding Q_n is lower than $-80 \cdot 10^{-11}$ K/ms exceeds 90%. By locating the front in the image and knowing the Q_n values within the front, further development of the frontal cloudiness can be predicted. If there are positive Q_n values within already strong frontal cloudiness, frontolysis is taking place and during the next few hours the percentage of the highest pixel values should rapidly decrease. Furthermore, if a Q_n minimum indicates frontogenesis, although the frontal cloudiness is not yet developed, strong development of clouds with cold tops can be expected in this region during the next few hours, provided the other conditions (especially moisture content) are favorable, too. The feasibility of using Q_n as an indicator for cloud development and perhaps its intensity is mainly inferred subjectively from case studies combining Q_n and IR satellite imagery rather than from the objective correlation statistics. Experience shows that the Q_n field combined with satellite images can contribute to nowcasting and forecasting in the next 6 to 12 hours in frontal cases.

REFERENCES:

Hoskins, B.J., Draghici, I., Davies, H.C., 1978: A new look at the ω-equation. *Quart. J. Roy. Meteor. Soc.*, 104, 31-38.

Kurz, M., 1990: *Synoptische Meteorologie.* Leitfäden für die Ausbildung im Deutschen Wetterdienst. Offenbach am Main: Deutscher Wetterdienst, 197 pp.

Strelec, N., Jann, A., Zwatz-Meise, V., 1997: Analysis of Frontogenesis and Frontolysis by Means of Q-Vector Diagnostics Combined With Satellite Images. *Met. Atmos. Phys.* 62, 23-31.

Verification results and possible consequences for the future weather service

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1. Introduction

During the last decades numerical modelling has revolutionized weather forecasting with increasing skill in forecasting surface weather. This trend will continue. Without models skillful forecasts beyond 2-3 days would be impossible. Corrections to forecasts have been necessary to capture local weather characteristics at specific locations. Objectively this has been accomplished by statistical corrections as well as with adaptive measures and the result has in most cases been an improvement that in many cases matches that of subjective forecasts, even if the forecasters had access to all available models and methods.

In this paper some recent verification results will be presented including the results achieved by forecasters. In the past forecasters have in most cases contributed significantly to the end results, but as the development of models continue to improve with regard to surface forecasts in particular, the gap is closing and there is nowadays only marginal improvements to be gained by a forecaster involvement. This means that the traditional interpretative role of the forecaster is bound to change; some regard the change to that of a pilot who normally sets the forecasting on automatic mode and only takes over when something goes wrong. This has been discussed by Roebber and Bosart (1996), who beleive that means must be found to polish and extend their forecasting skills by taking advantage of the technology that is driving the convergence between human and machine skills. They have also demonstrated that forecast skill is to a large extent determined by experience.

2. Verification of surface parameters

It is interesting to compare verification results between the forecast values produced by the best methods and those of the forecasters given that he/she had access to those values. The gain averaged over a rather long time such as season or year (Fig. 1) is not very significant anymore, except for certain weather situations or regimes, when models and methods somehow fail. During a number of years the forecasters have, in general, significantly improved daytime temperature forecasts during spring, due to the fact that numerical models over snow covered conditions, especially the ECMWF model, have displayed strong negative biases in the T2m, which was apparent also during spring 1997, but with much less amplitude. This has also had an adverse effect on the statistical and adaptive methods. However, in the persistent late summer/ early autumn period the performance of the forecasters has normally been less pronounced.

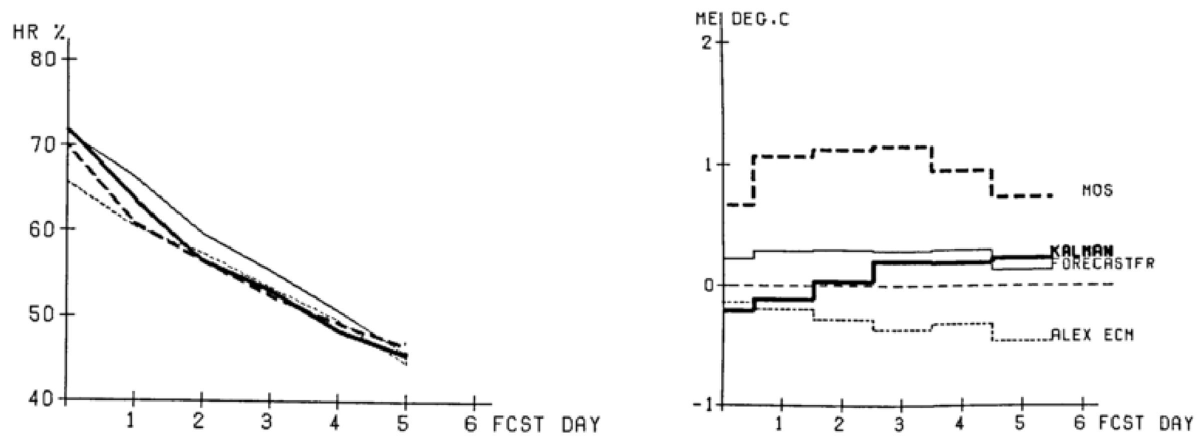

Fig. 1. Verification of 2mT at 12 GMT during the period 960701-970606 for 17 locations. Left: hit rate (% correct within +- 2 deg C), right: mean error (deg C bias). Thin solid: forecaster, thick solid: Kalman, thin dotted: adaptive model on ECMWF 2mT, thick dashed: Model Output Statistics.

Taking out only those forecasts where there was a minimum change of 5 degrees in either direction from one day to the next, forecasts that could be considered relatively more important to many customers, the forecasters are only occasionally performing well and many times the direct model output scores the best. This turns out to be attributed to the fact that the forecaster normally moderates strong changes and acts more "cautiously" and so does statistical methods like MOS, where the minimization of RMS-errors will dampen large changes, particularly for forecasts with longer lead times.

Forecaster:	50 %
ECMWF:	46 %
HIRLAM:	50 %
HIRLAM22:	51 %
Alex ECMWF:	43 %
Alex HIRLAM:	52 %
MOS:	45 %
Kalman Combi:	46%

Table 1. Hit rate (% correct within +-2 deg C) given temperature change of at least 5 deg /24 hrs. 00 GMT (+24- +48hrs) and 12 GMT (+12- +36hrs) mixed. Time period: 960701-970606. No of cases: 1946.

Categorical precipitation is a parameter for which direct model output for most of the time has been performing best, but occasionally marginal improvements can be achieved by various methods. We have no direct comparison with forecaster performance, but we believe that there is no real gain, possibly except for locations with very local character, where the forecaster or a method capturing the local effects can improve upon the model output. However, as orographical effects are being captured with increasing skill by the models with higher resolution there is less to be gained by methods or forecasters, who have a tendency to dampen heavy precipitation. Models have in the past produced too many events of small amounts of precipitation, which has been a problem, but also this problem seems to disappear with higher model resolution and improved physics.

Probabalistic forecasting of precipitation amounts can be well predicted by MOS or for longer lead times also by the ensemble forecasts (EPS). Comparative tests using <1 mm/6 hrs with 24 hour lead time have shown that the forecaster can normally only marginally improve on Brier score compared with MOS but has the abililty to somewhat sharpen the distribution by modifying the MOS probabilities to become closer to 0 or 100%, and this can be considered an improvement. However, the numerical models do not produce probabalistic forecasts directly, except for EPS, so we cannot draw direct conclusions as to the model performance relative to the forecaster. We could however from a statistical sample of model data and the corresponding observations get the observed frequencies when the model gives a prediction of exactly 1, 2, 3 ...mm etc. This method can be considered a MOS method with only one predictor, ie model precipitation amount, but is of course also a function of forecast accumulation time and lead time. For this method several observations have to be grouped together in order to get enough data and thus the local character is lost. Only data for 12 hr accumulation time has been available so no direct comparison has been made between forecaster and this method. Compared with "normal" MOS there is not so much to choose between the two methods.

Wind is another parameter which is not considered so important over land areas, except for the rather rare cases when strong gusty winds occur, which could lead to stuctural damage. Also for sea areas weaker winds are not very important but higher wind speeds are much more frequent over the sea. Our definition of gale force winds is when the 10 minute average wind exceeds 14 m/s, which is the lower limit for wind warnings for commercial traffic. A verification procedure where the forecaster has access to the categorical direct model values from ECMWF, HIRLAM, UKMO and MOS before making his/her own estimate for 4 selected light houses, considered to be representative. The forecast values are placed into two categories: below and above 14 m/s respectively. From the contingency tables it is interesting to see that the forecaster does not generally improve significantly on the model or MOS values and will receive approximately the same Percent Correct values or Hit Rate (HR), False Alarm Rate (FAR) and Probability of Detection (POD) as all the models and methods. Using probabilities of exceeding the gale-force limit the forecaster will normally marginally improve the Brier Score and sharpen the distribution somewhat.

Finally, cloud cover is a parameter which is difficult to observe and is exposed to human judgement. Thin cirrus clouds are the type for which most judgement occur and in dark conditions high thin clouds can normally not be observed. Also the "curtain effect" of cumulus clouds near the horizon will at times give rise to biases. MOS and adaptive forecasts of cloud cover and the direct model cloud cover have all improved considerably in recent years, especially the low level cloudiness has improved and the biases are reduced, so there is nowadays less scope for positive human intervention and impact. However, a small investigation from just one location indicates that the forecaster can still improve the model cloud forecasts (Table 2).

Table 2:
Gothenburg 960701-970531

No of cases: 1257	HIRLAM	HIGH RES HIRLAM	ECMWF	FORECASTER
MAE	2.2	2.3	2.1	1.8
ME (BIAS)	-1.0	-0.9	-0.1	-0.1
HR % (+- 2 OKTAS)	66	65	67	73

3. Changing role of the forecaster

At SMHI semi-automatic forecasting techniques have been in use for about 10 years. For some customers, for which a lot of tabular data is produced, a first guess from a statistical or an adaptive method is presented to the forecaster who can opt to modify the values before dissemination or send the final product to the customer unaltered if he finds the values acceptable. As models and methods have gradually improved there is today less need for intervention than 10 years ago, when sometimes all forecast values had to be changed and there was no saving of time at all. Today there are several products produced this way and there are plans to make this more efficient by letting the forecaster monitor and if necessary modify fields of forecast data, which is then stored in the "best estimate" database, from which all products will be produced, whether they are in tabular, graphical or textual formats. The role of the forecaster will therefore gradually be switched to that of a supervisor, who will select the model or method believed to be of best quality at that time, based on recent verification results and forecasters judgement. By using interactive tools comparatively quick modification to fields can be accomplished, should that be considered necessary (Nilsson, 1997).

The second, but nevertheless the most important, role of the forecaster is to focus on weather situations that pose a significant threat to public safety, the severe weather situations. There have been events of this character which have not been treated with the full alertness as could have been expected due to heavy workload of forecasters, especially in cases of severe and complex weather situations. With automatic supervision of forecast fields giving early warnings, sometimes already in the medium range, to the forecaster that there is a risk of severe weather, early planning of placing staff in standby mode can be achieved. For those events when an explosive unexpected weather development takes place the forecaster will be alerted as soon as observations exceed certain limits, in order to take the necessary steps to deal with the situation. Priority lists should be compiled. For other catastrophic events such as nuclear accidents, poisonous leaks etc, where weather information is vital, there must be plans and the staff trained to deal with the situations swiftly and correctly.

4. Summary and conclusion

There are indications that the traditional interpretative role of forecasters is diminishing due to the continuing convergence of human and machine skills. This has been shown in verification of different surface parameters where the forecaster, although given the forecast from different model and methods, is normally only marginally able to improve on the best forecast estimates given by models or methods. For temperature human verification results are in general superior during spring, whereas there is no significant improvement in late summer and early autumn, when situations normally are quite persistent. In situations when temperature changes more than 5 degrees in 24 hours the forecaster performance is often exceeded by other forecasts due to cautiousness by forecasters. Also with regard to precipitation, wind and cloudiness forecasters can only in certain situations make a significant improvement, in others there is none observed.

Therefore the future role of forecasters has been briefly discussed. The most important task for forecasters in the future weather service will be to focus on severe weather and warnings, but supervision of model/ method performance and interactive forecast field intervention based on recent verification results will also be needed.

5. References

Nilsson, S., 1997: Use of Graphical Interaction within the RiPP Project. Preprints, *report of the EGOWS-97 meeting, Toulouse, France* (to be published).

Roebber, P. J. and Bosart, L., 1996: The Contributions of Education and Experience to Forecast Skills, *Wea. Forecasting,* **11**, 21-40.

ON THE POSSIBILITY OF SEASONAL FORECASTING IN NORTHERN EUROPE

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ABSTRACT

We present some recent work on the possibility of seasonal forecasting in northern Europe. The work is based on an empirical methodology, canonical correlation analysis (CCA), which is a method designed to find correlated patterns between predictor and predictand fields. The technique is used to explore the level and origin of seasonal forecast skill of surface air temperature in northern Europe. We use a modified form of CCA where a prefiltering step is preceding the CCA as proposed by Barnett and Preisendorfer. The predictive potential of four fields is investigated, namely a) surface air temperature, i.e. the predictand field itself, b) local sea surface temperature (SST) in the northern European area on a dense grid, c) Northern Hemisphere 700 hPa geopotential height and d) quasi-global SST on a coarse grid. The design is such that four contiguous predictor periods (of 3 months each) are followed by a lead time and then a single predictand period (3 months long). The shortest lead time is 1 month and the longest is 15 months. The skill of the CCA-based forecasts is estimated using cross-validated hindcasting. Skill estimates are expressed as the temporal correlation between the forecasts and the respective verifying observations.

The skill of the seasonal forecasts is much more a function of the target season than of the forecast lead time. The forecasts are most skillful in the winter seasons with a secondary weaker skill maximum during summer. The decay of skill with increasing lead time in the most skillful seasons is rather slow, which indicate that the source of the skill comes from phenomena of very low frequency. During winter the geopotential height field produces the highest skill scores of the four predictor fields. The dominant predictor pattern of the geopotential height field is confined to the predictor period which is closest to a preceding core winter season and resembles the North Atlantic Oscillation (NAO) teleconnection pattern. The time series of the expansion coefficients of this dominant predictor pattern correlates well with a low-pass filtered time series of an NAO index. The obtained skill is similar to what is found in the USA, both with regard to seasonal distribution and level of skill. The origin of skill is however different. In the USA it is the El Niño-Southern Oscillation (ENSO) with its predominantly interannual character that is the main source of skill. In northern Europe it is instead the NAO that contributes the most, and especially the lower frequency part of the NAO (periods between 4 and 10 years).

SEASONAL PREDICTABILITY EXPERIMENTS AT ECMWF

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ABSTRACT

An extensive set of 120-day ensemble integrations of a version of the ECMWF numerical weather prediction model have been made with prescribed observed sea surface temperatures. The purpose of these ensemble integrations is to determine the predictability of the atmosphere on seasonal timescales, given the correct forcing from the underlying oceanic boundary. Each ensemble comprises 9 members, and the integrations are made each season over the ECMWF reanalysis period from 1979-1994. The reanalysis data is used both to provide initial conditions and to verify the integrations. Seasonal predictability is assessed as a function of a) region, b) time of year, c) state of El Niño, d) variable. Results will be shown both for Europe and for other parts of the world. Additional experiments will be described in which the influence on atmospheric development of the initial conditions and the sea surface temperature anomalies can be isolated.

RECENT IMPROVEMENTS IN SEASONAL FORECASTING IN THE UKRAINIAN METEOROLOGICAL SERVICE

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This paper is based on recent advances in seasonal forecasting in the Ukraine, focusing on operational system that was developed by the Laboratory of Climate Research (LCR) of the Ukrainian Hydrometeorogical Institute. The LCR has made forecasts mean month temperature and the month sum of the precipitation for the for the Europe and Ukraine issued on 40 days before this month. The refined forecast is issued on 10 days before target month. The detailed forecast of important meteorological events (strong cold, warming (±6-10°C), strong precipitation, drought, storm etc.) at this month is given. From January 1987 LCR forecasts are official in the Ukrainian Hydrometeorological Service. Three key approaches is used in this operational system:

- "Floating analogue" method;
- Two-month quasiperiodicity;
- "Ethalon-field" approach.

For the developed by LCR method of the seasonal forecasting there are the underlying a ``floating analogue'' method (FAM), that was developed Martazinova and Sologub (1986). The FAM generalises the well-known methods of analogues selection. Unlike the conventional approach the FAM requires only geometrical similarity of the planetary high-level frontal zone (PHLFZ). The limiting conditions of the coincidence in time and space are lifted.

A statistical analysis of the position of PHLFZ in the Northern Hemisphere at 1964-86 was carried out using analogy criterion by the sign of an anomaly ρ and mean square distance between the fields η. and two-month quasiperiodicity of the large-scale atmospheric processes in the Northern Hemisphere. The quasiperiodicity in the structure of the PHLFZ was studied with a lag from zero to three months. Use of FAM made it possible to reveal the two-month quasiperiodicity of atmospheric processes in the troposphere (Martazinova V.F., Sologub T.A.,1986; Martazinova, 1989) that had not become known by the traditional methods of the analogue selection. The Table 1 shows that displacements of the two-month analogues are under the seasonal changes. This is because a seasonal latitudinal migration of PHLFZ and the longitudinal shift of PHLFZ that is connected with a change sign of the gradient land-ocean.

The forecasting procedure allowed to calculate the fields of temperature, pressure and precipitation using field-analogues with two-month lag. The strong changes of weather within month are predicted using statistical ethalon fields approach. The "ethalon field" was used for classification of meteorological fields as in the climate research as in the long-range forecasting (Sologub, 1989; Martazinova V. F. et al., 1991). The ethalon field is a field with the minimal mean square distance η with the others fields from given set. The catalogue ethalon-analogues and ethalons with two-month lag with anomalous weather conditions that followed by snowfalls, strong rain, storms, thunderstorms, droughts, strong warming and cold etc. was compiled. As example, in fig.1 the ethalon field and ethalon-analogue of geopotential at 500 mb

Table 1. The displacement of the two-month analogues relatively of the initial geopotential field at mean level.

Month	Month-analogue	Shift $\Delta\varphi^0$	$\Delta\lambda^0$
March	January	0	-10
April	February	-5	-5
May	March	-5	-10
June	April	-5	-15
July	May	-10	0
August	June	-5	+20
September	July	-10	+20
October	August	0	+15
November	September	10	+15
December	October	5	±15
January	November	0	-10
February	December	0	-10

level with surplus and deficit of precipitation are given. These ethalon-analogues are used for prediction of strong weather changes.

The analysis of the forecast skill for 25 regions of the Ukraine for 1992-1996 showed that the skill of the temperature forecasts has been appreciable. The mean skill difference of monthly mean surface temperature forecasts from climatology was 20% whereas skill excess over persistence forecasts was 24 %. Mean skill difference of the monthly sum of precipitation forecasts from climatology was 11% and the mean skill difference forecast from persistence forecasts was 17%.

References

1. Martazinova V.F., Sologub T.A. (1986) The determination of quasiperiodicity of the atmospheric processes in Northern Hemisphere by method ``floating analogue" Trudy Ukr NIGMI, **219**, p.37-42 (in Russian).
2. Martazinova V.F. (1989) The implication of the dynamics of ultra-long waves in the analogue forecast Trudy Ukr. NIGMI, **233**, p.70-75 (in Russian)
3. Sologub T. A. (1989) Ethalon fields of drought atmospheric processes over the Ukraine. Trudy Ukr. NIGMI, **233**, p.87-92 (in Russian)
4. Martazinova V. F., Sologub T.A., Ivanova E.K., Matsak V.V. (1991) Anomalous atmospheric processes over the Ukraine and their forecast with month Trudy Ukr. NIGMI, **239**, p.63-69 (in Russian)

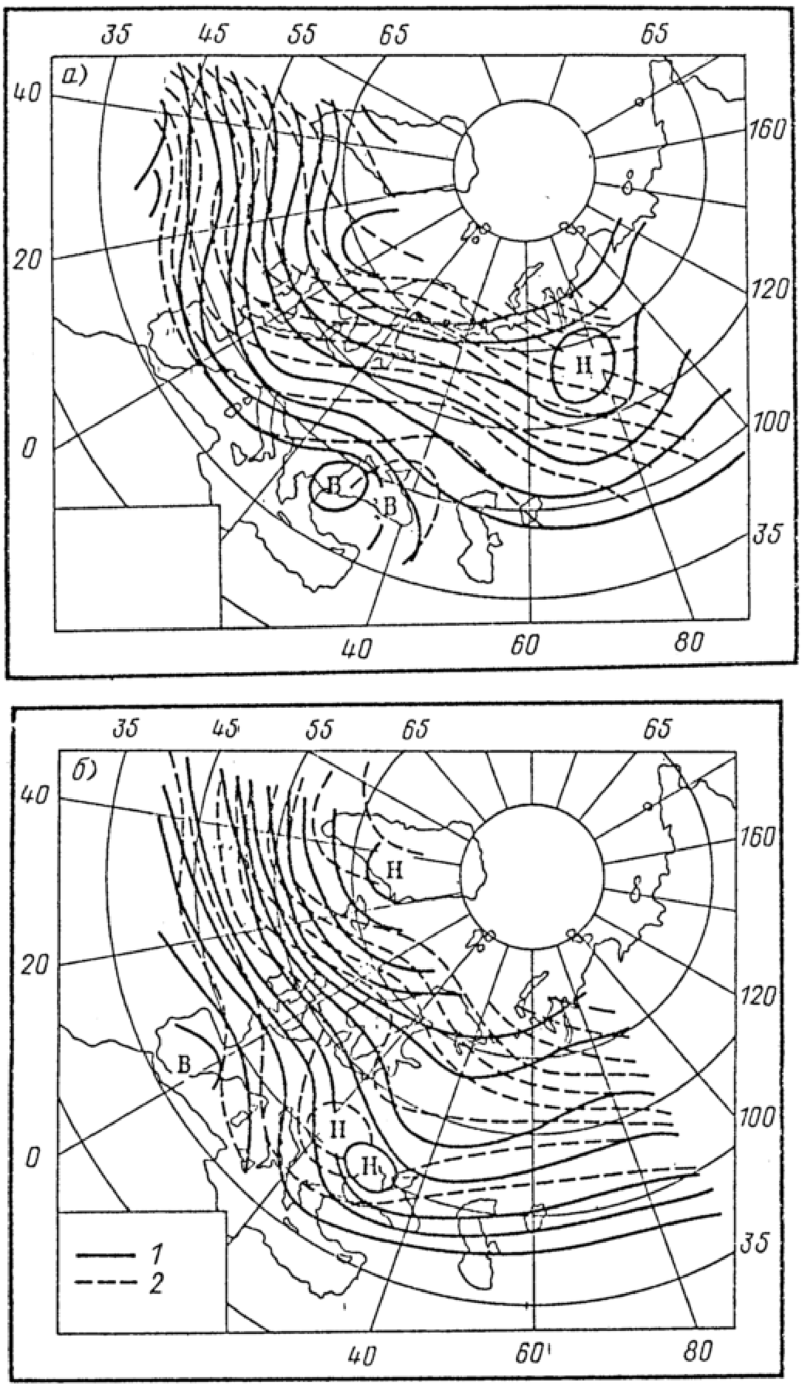

Fig.1 The ethalon of geopotential at 500 mb level with precipitation deficit (a) and precipitation surplus (b) in July (1) and its ethalon-analogue in May (2).

Long-term prognosis of the monthly mean temperature for the Berlin area

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1. Introduction

In short- and medium-range weather forecast numerical methods lead to forecasts with high accuracy. In long-range weather forecast the statistical approach seems to be more appropriate. Baur (1958) was one of the first to examine large-scale weather systems in order to predict the temperature of the following months. He found out that in certain seasons the pressure patterns show a tendency of persistence whereas in other seasons the tendency of circulation changes dominates. Analyzing "farmer rules" Malberg (1989) discovered correlations between monthly mean temperatures of, for example, October and the following winter season: If October in Berlin is at least 1.5 K colder than normal, then the following January / February will be warmer than normal with a probability of 65% / 75%. Under consideration of these results we started to examine the sea level pressure and the 500-hPa-geopotential height over the North Atlantic and Europe to predict the monthly mean temperature of the following months for the Berlin area.

2. Data and Methods of Analysis

The data basis of this method are the monthly means of sea level pressure (slp) and 500-hPa-geopotential height (geo) from 1954 to 1991 which exist as 5° to 5° gridpoints of the North Atlantic / European region. For each months separately these data sets are clustered with the help of the monthly mean temperature of Berlin, e.g. January, into three classes: warmer than normal / normal / colder than normal. The dividing criterion is the standarddeviation, so that, differing from month to month, between 5 and 10 cases fill each extreme class (warmer / colder than normal). These 5 to 10 cases of each extreme class are taken to define two average pressure patterns (slp and geo) which lead to a significantly warmer or colder monthly mean temperature, e.g. of January, in the Berlin area.
For the example of January we now have the two average pressure patterns of September, October, November and December, which lead to a cold/warm January in the Berlin area. For each preceding month (Sep.-Dec.) and for each element (slp and geo) the two pressure patterns are tested for significant differences by the two-sided Student-t-test.

3. Long-term forecast of monthly mean temperature for the Berlin area

The test for significance reveals that basically the slp and geo in regions far away from Central Europe are decisive for the temperature of the following months in the Berlin area. These "significant regions" differ from month to month and are situated, for example, over Greenland, Iceland, Scandinavia, Labrador, the Azores or the Mediterranean. The prediction of the monthly mean temperature in the Berlin area can be derived from the slp- and geo-values of the preceding months in these "significant regions".

4. Verification

Since the summer of 1992 long-range forecasts of the monthly mean temperature of the following three months for the Berlin area are routinely published every month by the Meteorological Institute of the Free University of Berlin (Berliner Wetterkarte, 1992-1997).

Fig. 1: Reduction of Variance

Forecasts for 1, 2 and 3 months ahead

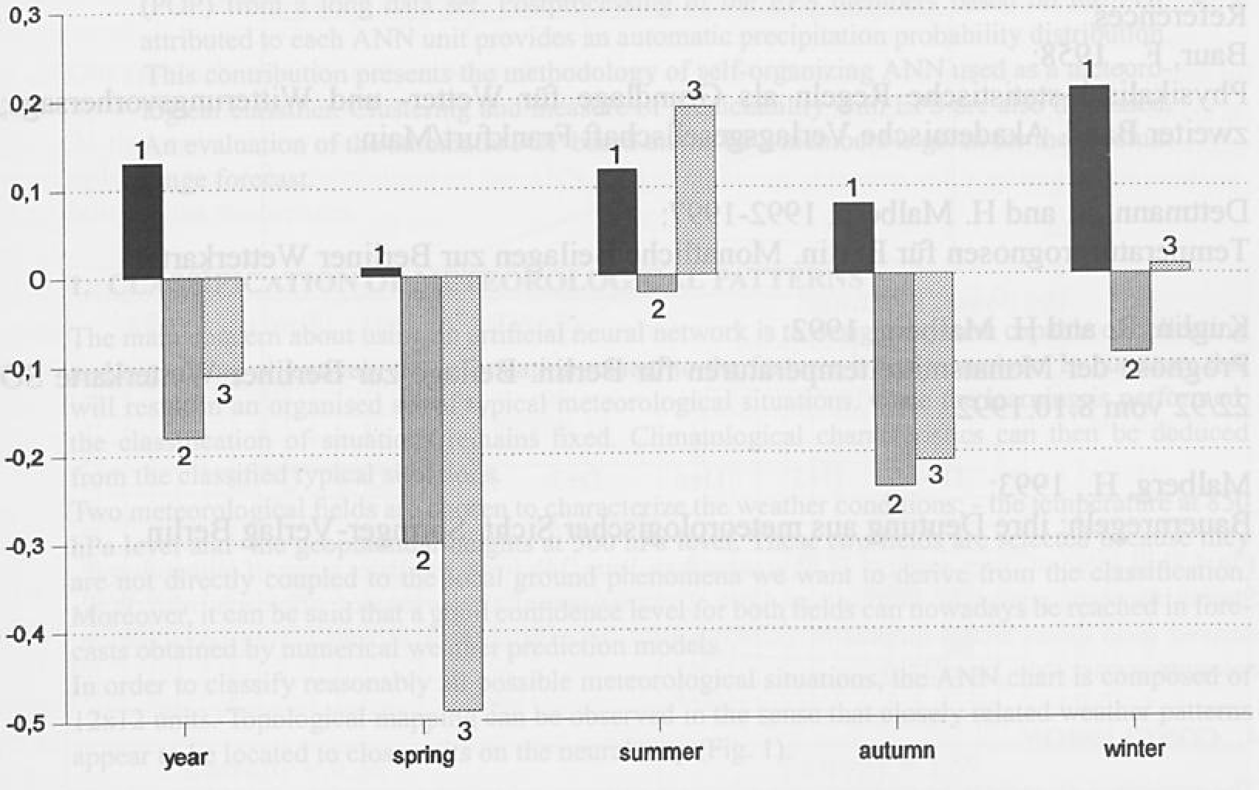

Fig. 1 shows the reduction of variance (RV) of the one-, two- and three-month forecasts in the whole year and in each season, compared to climatology. The one-month forecast can be found in all seasons above zero, reaching the maximum in winter with RV= 0.21. The two-month forecast is always below zero, with the best value in summer. The three-month forecast reaches values above zero in summer and winter, whereas in spring, autumn and the

whole year negative values of RV can be found. It is surprising that the three-month forecast is, in the average, better than the two-month forecast.
Regarding the seasons one can conclude that the best long-range forecast are possible in summer and winter, whereas in spring and autumn forecasts exceeding one month are worthless.

5. Discussion and Outlook

Long-range forecasts are of different value in each season of the year. The best results can be reached in summer and winter. By contrast in spring and autumn forecasts should not exceed one month. These results are in accordance with the numerical weather prediction which has its minimum of RV in spring, too.
For the future we intend to enlarge the data basis in time and space, so that we will have a complete data set of 50 years of the whole Northern hemisphere. At the same time we will try to extend the forecasts up to six months at least in summer and winter, because in these seasons the three-month forecast shows sufficient reliability to dare this step.

References

Baur, F. , 1958:
Physikalisch-statistische Regeln als Grundlage für Wetter- und Witterungsvorhersage; zweiter Band. Akademische Verlagsgesellschaft Frankfurt/Main.

Dettmann, R. and H. Malberg, 1992-1997:
Temperaturprognosen für Berlin. Monatliche Beilagen zur Berliner Wetterkarte.

Kuglin, R. and H. Malberg, 1992:
Prognose der Monatsmitteltemperaturen für Berlin. Beilage zur Berliner Wetterkarte SO 22/92 vom 8.10.1992.

Malberg, H., 1993:
Bauernregeln: ihre Deutung aus meteorologischer Sicht. Springer-Verlag Berlin.

AUTOMATIC PROBABILITY OF PRECIPITATION BASED ON ENSEMBLE PREDICTION SYSTEM

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ABSTRACT

The ECMWF Ensemble Forecast System (EPS) is presently being introduced into the operational weather forecasting environment of the Swiss Meteorological Institute. The classification of the members of EPS is achieved with the help of an artificial neural network (ANN), which results from a 12 year learning of analysed situations.
Moreover, the probability of occurrence of any weather parameter can be attributed to each neural unit of the ANN. As a first step, we derived the probability of precipitation (POP) from a long data set. Postprocessing of the EPS members based on the POP attributed to each ANN unit provides an automatic precipitation probability distribution. This contribution presents the methodology of self-organizing ANN used as a meteorological classifier. Clustering and measure of predictability with EPS are also discussed. An evaluation of the automatic POP based on the EPS members is given for the medium range forecast.

1. CLASSIFICATION OF METEOROLOGICAL PATTERNS

The main concern about using an artificial neural network is to design a system capable of collecting and organising objectively the information related to the features it has to analyse. In our case, this will result in an organised set of typical meteorological situations. Once the learning is performed, the classification of situations remains fixed. Climatological characteristics can then be deduced from the classified typical situations.
Two meteorological fields are chosen to characterize the weather conditions; - the temperature at 850 hPa level and -the geopotential heights at 500 hPa level. These two fields are selected because they are not directly coupled to the local ground phenomena we want to derive from the classification. Moreover, it can be said that a good confidence level for both fields can nowadays be reached in forecasts obtained by numerical weather prediction models.
In order to classify reasonably all possible meteorological situations, the ANN chart is composed of 12x12 units. Topological mapping can be observed in the sense that closely related weather patterns appear to be located to close units on the neural map (Fig. 1).

2. ENSEMBLE PREDICTION SYSTEM

The basic idea of the Ensemble Prediction System (EPS) is that the analysis used in a numerical weather model is always an approximation of the reality. As the atmospheric system is known to be chaotic, the numerical forecast will deviate from the real solution depending on the quality of the initial analysis. Perturbations on the initial state are introduced in order to evaluate how much the forecast is sensitive to this initial state. The ECMWF EPS is presently composed of 50 runs of the same model, with small perturbations on the initial state. This leads to a flood of data from which signals about the predictability of the atmosphere and probabilistic forecasts must be extracted.

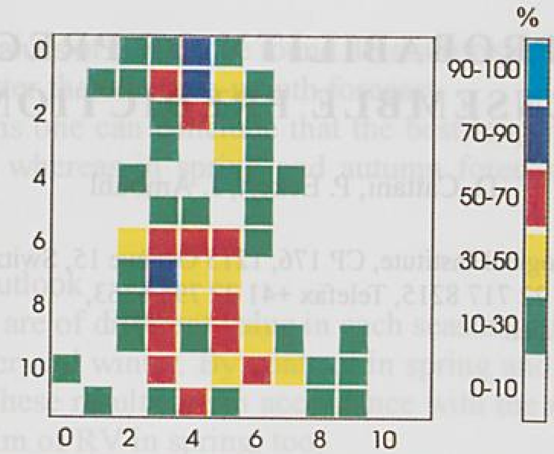

Fig. 3 Probability of precipitation greater than 10mm/day in Locarno attributed to each unit of the ANN chart. Period of statistics is 1981 to 1995.

By combining the distribution of EPS members on the ANN chart and the corresponding probability of precipitation, local POP are deduced automatically for medium range forecasts.
A verification of the probability of precipitation obtained by this technique shows an important improvement of this type of forecast with respect to the direct model output (Figure 4).

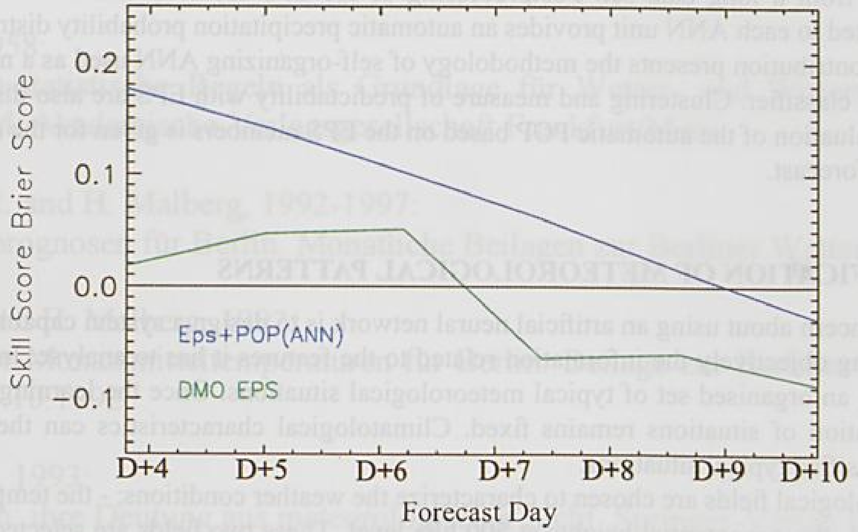

Fig.4 Skill score of Brier score of POP greater than 1mm/24h (over the Brier score of climatology). Station Geneva, period of verification 1996. Comparison of the presented approach with POP derived form direct model outputs of ECMWF EPS (relative number of runs giving precipitation amounts greater than 1mm/24h).

4. CONCLUSION

The presented classification technique is adequate to meteorological patterns, because it conducts successfully to a realistic classification of typical weather situations. The ANN chart possesses the required meteorological relevance. When a large set of runs are classified, the overview ANN chart of the whole network allows an intuitive estimation of predictability, assessed by a measure of entropy.
Moreover the derived parameters (such as the local precipitation) associated to the network units show that climatological knowledge is involved in the learnt typical situations. Therefore a substantial improvement in local weather forecasts is reached by introducing the classification as post-processing of the numerical weather forecasts.

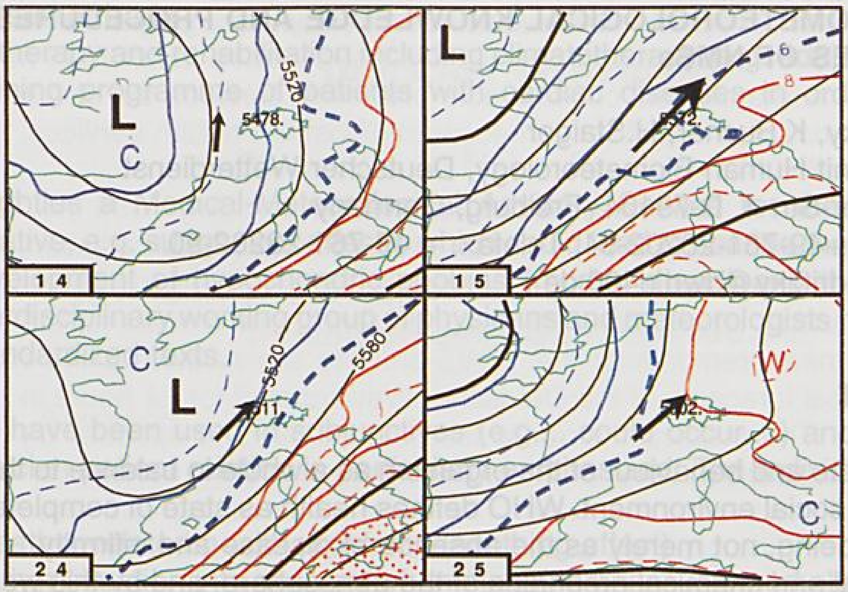

Fig. 1. A four unit subset of the resulting self-organized ANN chart representing the two levels, respectively the temperatures at 850 hPa (blue and red) and geopotential heights at 500 hPa (black).

Our approach consists in classifying all members of EPS within the 144 typical situations learnt by the neural network. By analysing the distribution of the elected units corresponding to each run (Fig. 2), the predictability can be evaluated. We suggest to apply the entropy as a measure of the order/disorder degree of the distribution on the ANN map to obtain an objective value related to the predictability of the atmosphere.

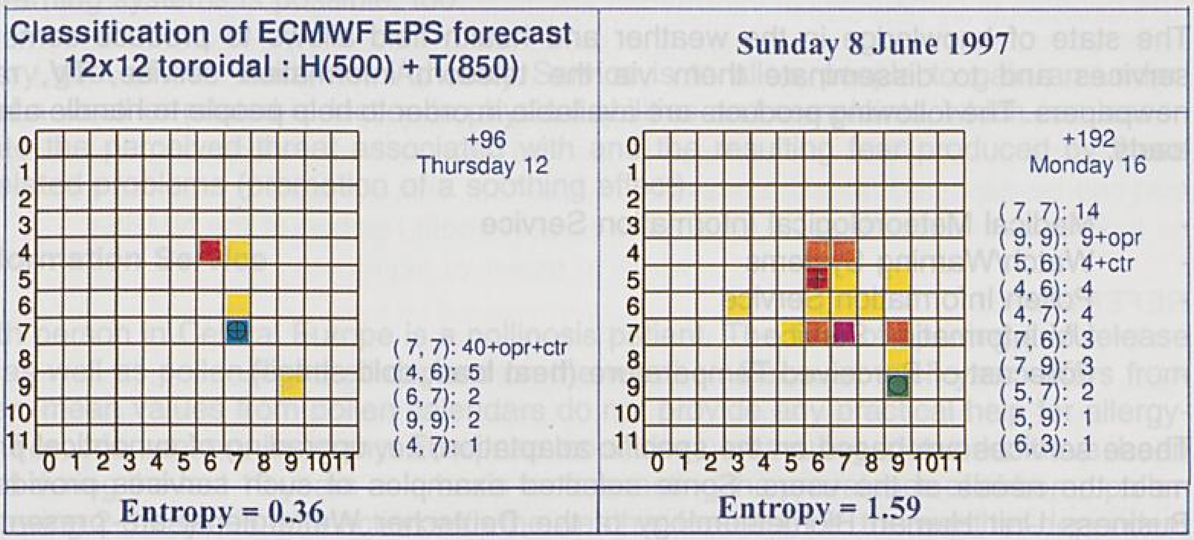

Fig. 2. Distribution of elected units on the ANN map, at the forecasting day D+4 and D+8, positions of the operational and control forecasts runs are indicated respectively by *opr* and *ctr*.

3. PROBABILITY OF PRECIPITATION

Once the network is fixed, local weather parameters may be derived from the classified typical situations. Statistics are computed for local precipitation amounts. Figure 3 shows the probability of precipitation amount greater than 10 mm/day in Locarno (Switzerland) related to each unit of the ANN map.

The topology of the artificial neural network agrees to climatological requirements by grouping together the rainy situations on the map (Fig. 3).

USE OF BIOMETEOROLOGICAL KNOWLEDGE AND PROCEDURES IN SERVICES OF NMSs

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ABSTRACT

Health is state and behaviour of the organism as a whole in balance to the interactions with the natural and social environment. WHO defines health as state of complete physical, mental and social well-being, not merely as the absence of disease and infirmity.
The physical and chemical properties of the atmosphere, and by this weather and climate, are part of our environment. In order to maintain health, well-being, and performance the human organism is in a permanent state of confrontation with this environment. Adaptive reactions of the organism therefore can be taken as a response to disturbances by the atmosphere. A healthy organism will accomplish adaptation by means of the autonomic regulation, which mostly goes unnoticed. The adaptability of sensitive, elderly, and sick persons, pregnant women, and children is, however, more liable to be overtaxed. Epidemiological studies show effects of extreme conditions (heat load, cold stress, air pollution incl. pollen, and weather changes) on morbidity and mortality, but also on subjective impairments in well-being.

The state of knowledge in the weather and health field allows to produce some advisory services and to disseminate them via the telecom information service, TV, radio, and newpapers. The following products are available in order to help people to handle atmospheric loads:

- Medical Meteorological Information Service
- Watch/Warning Systems
- Pollen Information Service
- UV-Information Service
- Forecast of Perceived Temperature (heat load, cold stress).

These services are based on the specific adaptation, i.e. upgrading of synoptical products to meet the needs of the users. Some selected examples of such services provided by the Business Unit Human Biometeorology of the Deutscher Wetterdienst are presented in the following:

Medical-Meteorological Information ServiceMedical-Meteorological Information Service

The results of epidemiological studies on relationships between weather events and medical data produce a very coherent picture of biotropy. Biotropy is understood as an additional stress to which the organism is forced to react in order to remain in good health.

The Deutscher Wetterdienst delivers physician-oriented forecasts with significant information on health effects due to increased weather stress. This service can be applied e.g.:

- to minimize the risk of complication during anaesthesia, postoperative embolism and postoperative haemorrhage

- within physical therapy and rehabilitation including climatotherapy (e.g. adaptation of the therapeutic training programme of patients with cardiac diseases in order to avoid incidents).

At the end of the eighties a Medical-Meteorological Advisory Service for the public was initiated. To avoid negative, e.g. suggestive effects, which could lead to scaring the population, connected with a development of hypochondric phobias (morbid dread) and the "breed of meteoropaths", an interdisciplinary working group of physicans and meteorologists has formulated a catalogue of standardized texts.

Cautious formulations have been used in subjunctives (e.g.... could occur....) and the importance of a stable physician-patient relation is particularly emphasized. The individual learns

- to recognize weather-related health problems (soothing-effect)
- to take the weather situation into account when planning unaccustomed physical strain (avoidance of overstrain)
- to adapt medication and cure measures according to prior agreement with the family doctor (cardiac patients, persons suffering from pain, etc.).

Since 1994 this service has been expanded by information on heat load or cold stress, respectively, applying a complete heat budget model of the human being on the output of the numerical weather forecast model. The parameter is a so-called Perceived Temperature which relates the thermal conditions to a standardized environment. The application of this procedure in watch/warning systems is possible, too.

The primary goal of this Med.-Met. Advisory Service is to allow people to gain an understanding of a weather-related reduction in physical abilities and complaints, which can lessen or eliminate the perceived threat associated with and the resulting fear produced by these weather-related problems (promotion of a soothing effect).

Pollen Information Service

Every tenth person in Central Europe is a pollinosis patient. The time of ripening and release of pollen, as well as pollen flight, all depend on the weather. Because each year differs from every other, mean values from pollen calendars do not provide any practical help for allergy-sufferers. For this reason, in many European countries, measuring networks have been established during the last 10 years as a basis for forecasting the prevalence of airborne pollen for the following 2-3 days, in connection with the weather forecast, i.e. the weather-dependent diffusion conditions (esp. wind, precipitation). The forecasts help

- to minimize the consumption of medicine
- to diminish lost work hours by proper prophylaxis.

UV Information Service

The UV-B (280 - 315 nm) has the most important effect on the organism of the biosphere. Besides the solar elevation, the ozone optical thickness is due to variations in UV-B radiation.

The favourable effects on human beings are the synthesis of vitamin D_3, indirect suntanning, and epidermal hyperplasia. But the adverse effects predominate: There are acute effects: sun-burn and immunosuppression and chronic effects: photoaging of human skin and skin cancer. The skin cancer incidence has risen in the last decades faster than nearly any other cancer, causing the dermatologists considerable problems. Besides the utmost concern for the individual, skin cancer is related to high economic costs in health services.

For this reason the Deutscher Wetterdienst initiated in July 1994 the "UV-Index". The objectives are to increase the public awareness of variations in UV radiation, and to contribute to an altered attitude of the individual to sun exposure. The baseline of the service is a forecast of total ozone and its distribution with height. In regression models for the twelve months the mid-day ozone measurements of the TOVS-satellite are related to the results of the numerical meteorological forecasts of the Deutscher Wetterdienst for 24 hours in six layers between 700 and 50 hPa. The prediction error is less than 5 %. The spectral UV radiation reaching the ground is computed at 80 grid points over Germany using a radiation transport model for the case of a cloud free atmosphere. The aerosol scattering and absorption is that of a light aerosol loading, the ground albedo is constant with that of green farmland. The UV spectra are weighted with the CIE action spectrum for erythema in human skin. This biological effective UV irradiance (mW m^{-2}) is divided by the constant 25 to compute the UV-Index according to the Canadian procedure. The values of the forecasted UV-Index are related to the forecasted conditions of sky condition (clouds) and weather. The information to the public includes messages of a sun smart life style e.g., use UV protecting sunscreen, avoid the mid-day sun, seek a shady spot, wear UV rated sun glasses, clothes and hat under the sun.

CONCLUSION

The benefits of climatological information are usually not realized before their application. The selected examples have made clear that human biometeorology possesses numerous tools to meet the needs of the users. The general aim is always to avoid or at least to diminish unfavourable effects, to take advantage of welfare effects, and to improve the quality of life of the general public. Thus the services presented for health and increasing wellbeing are those that can be expected from the activities of NMHSs. This will lead to national economic as well as individual benefits and will improve the cost/benefit relation of the NMHSs.

REFERENCES

AES,1993. UV Index Data Interpretation. National Monitoring and Services Division, Atmospheric Environment Services, Ontario. Originating Authority: Weather Services Directorate

Bucher, K. and Haase, Chr. 1993. Meteorotropy and Medical-Meteorological Forecasts. Experientia Vol. 49, No. 9, 759-768

Henriksen T., Dahlback A., Larsen SHH, Moan J., 1990. Ultraviolet-radiation and skin cancer. Effect of an ozone layer depletion. Photochemistry and Photobiology 51: 579-582

Jendritzky, G. and Bucher, K., 1993. Medical-Meteorological Fundamentals and Their Utilization in Germany. In: (ed.) A. R. Maarouf. Proceedings of: The Weather and Health Workshop. Nov. 19-20, 1992 Ottawa, Environment Canada, , 42-59

Jendritzky, G. and Kalkstein, L. 1997. Climate Services to the Health Sector. WMO-Bulletin Vol. 46, No. 1., 30-32

Puls, K.E. and Bock, K.-H. 1993. Pollen Flight Forecasting in Germany and in Europe. Experientia Vol. 49, No 11, 943-946

WHO 1994. Environmental Health Criteria 160, Ultraviolet Radiation, Geneva

The Digital Newspaper Weather Map of the Deutscher Wetterdienst

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Abstract:

In recent years the demands made on the media, especially for graphic presentation and comprehensibility of the weather forecasts, have increased steadily. The reason for this is inter alia the emergence of private service providers and the resulting competition with state meteorological services. At the same time, more powerful computer systems and continued improvement of the forecast models make it possible to provide many and diverse kinds of weather information with increasing accuracy.

In order to be able to supply the print media with state-of-the-art material, the Deutscher Wetterdienst (DWD) began in 1994 with the development of a new system for presenting the weather in newspapers.

Priority was given to the following points in the development:

1. The weather information should be available in digital form ready for printing and transmitted to the editorial system of the respective newspaper by means of modem.

2. In order to keep production costs low, manual work for producing a newspaper weather page should be minimized.

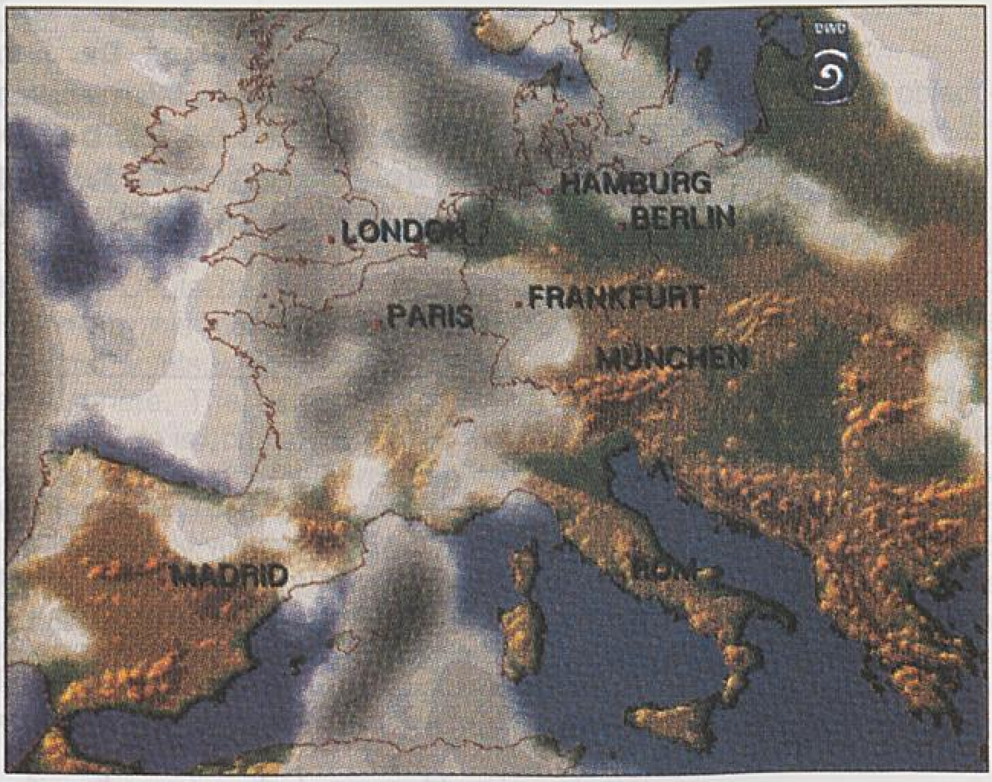
3. The increasing abundance of weather information available (e.g. forecast texts, measured values, spatial-temporal prognosis, meteorological fields, diagrams, etc.) should be made use of and, if required, be able to be elaborated.

4. At the same time the desire of many newspapers for an individual weather layout should be complied with.

The result is the demand for the system used to be compatible with the graphic systems used by the print media. It should also be interconnected with the data sources and production systems available at the DWD.

The result of this development work is the digital newspaper weather map of the DWD. It is based on the expansion of the widespread DTP (desktop publishing) programme QuarkXPress and has been used in its present form for a good year now for the routine production of newspaper weather pages in the Media Division of the DWD.

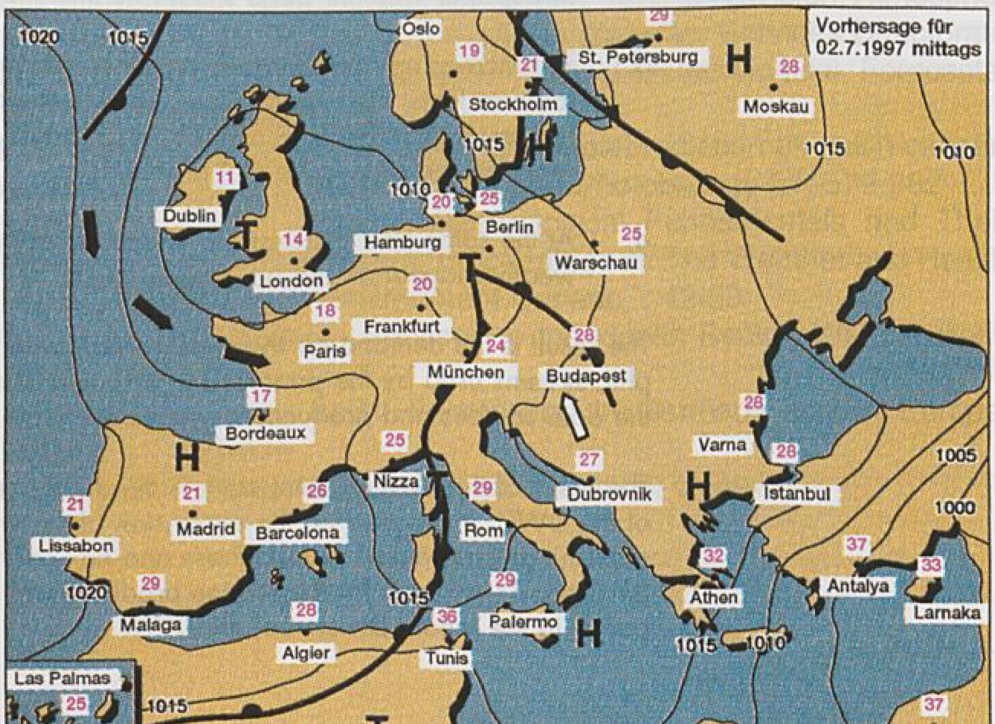
fig. 1
cloud forecast Europe on basis of the EM



QuarkXPress is a layout programme orientated towards boxes, i.e. texts and graphics are loaded into boxes and can then be moved and changed at will at the side. It runs both under Windows on a standard PC and on the Apple-MacIntosh computers usual in the graphic world.

The whole of the up-to-date model chain of the DWD (at present GM, EM, DM) serves as the basis (see fig. 1) as well as their Kalman-filtered forecasts, the products of the central forecast (see fig. 2) and the regional centres. These are then further processed by experienced media meteorologists and supplemented by forecasts compiled individually for the newspapers.

fig. 2
Forecast Map of Europe temperatures, fronts and isobars



In the daily production the software first filters out the information needed in each case. Then these data are put into graphic form, according to the customers' requirements, and automatically combined to make up a completed weather box (see fig. 3, example Welt am Sonntag).

Fig. 3 *completed weather box, example "Welt am Sonntag"*

The building-block construction procedure is used here, i.e. single elements can be exchanged at will. This flexible system has proved to be successful in practice.

A final check by the media meteorologists assures the quality standards predetermined by the DWD. In the final work step the data file ready for print is then transmitted directly into the computer system of the newspaper via ISDN.

(INT\Ecam-adr\A-Thomalla)

The TV weather report, a daily struggle about the weather: show, television production, entertainment and information

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Abstract

The independent weather desk of the ZDF in Mainz was established in 1963. Today, it is staffed by ten meteorologists.

The information for the daily weather report is supplied by the forecasting models of the Deutscher Wetterdienst (German weather service) and the ECMWF in Reading. Our own proprietary graphics software enables us to design anywhere from three to eleven daily weather forecasts, all of which are presented by professional meteorologists. Ever greater requirements are placed on the software, such as sophisticated colour design, direct conversion of the weather model computations into TV-compatible pictures, 3-D visualizations and flyby graphics or virtual weather studios. The meteorologist becomes the kingpin of a small weather show, surrounded by all manner of technology complete with ist potential pitfalls. Not even your weatherperson is immune to a breakdown of the graphics system in the middle of a presentation (some examples from the lives and times of ZDF meteorologists are given below).

At a TV station such as the ZDF, the „weather" has always been part and parcel of the „news" desk. Therefore, prognosticating the weather at the end of every news show used to be a „must". As early as 1992, the ZDF decided to separate the weather forecast from the main evening news with a brief commercial break. This made TV weather equally important to both television programmers and the advertising industry.

Those in charge at the stations are moving the television forecast onto a kind of playground where entertainment, fun and a happy-go-lucky attitude are the name of the game. This can be both a danger and an opportunity for us, the meteorologists, and the TV weather.
Their opposite numbers in the advertising agencies have realized that ratings stay high during the commercial break before the weather report. Thus a financial windfall of several million Deutschmarks has accrued for the ZDF. Before anyone gets the wrong idea - our ZDF prognosticators are not entitled to a share.

Under these new conditions, outsiders are exerting a growing influence on the weather forecasts. The meteorologist must not become an opportunist, of course. His credentials as a meteorologist just about convey the image of the viewers. In the long run, however, he may be tempted to make less well-founded claims about the weather god's intentions, thus undermining the reputation of a whole class of professionals.

A TV forecast presented by a good, independent meteorologist should inform the audience and keep it glued to the drama of an approaching cold front. Such a forecast should consist of diverse elements, use attractive graphics and not be averse to a sprinkling of fun and humour. As specialists in a small scientific field, it is especially incumbent upon us, the meteorologists, to become freer in order not to lose contact with the viewers. We are not short of good sales people to support us, so „the show must go on, but not without meteorologists".

METEOROLOGICAL ADVICE IN SERVICE OF AQUATIC SPORTS

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ABSTRACT

There are no sports which are more weather - dependent than aquatic sports. Weather forecasts for sailing and surfing have to ensure both personal security and, sometimes, furthermore the preservation of life. Therefore in particuliar aquatic sportsmen are interested in reliable forecasts of wind, weather and the state of sea.

The potential field of practical application of the forecasts has widened during the last two decades because of the development of the aquatic sports sailing and surfing from an exclusive leisure - time enjoyment towards a sport of the masses. In the same time the quality of the short - range and medium - range weather forecasts of the national weather services has been remarkably improved due to improvements of the numerical models. Thus the quality of the short - range forecasts, for example, has nowadays an accuracy of nearly 90%.

Nevertheless, the majority of aquatic sportsmen find the public services' weather information unsatisfactory. The reason lies, on the one hand, in the specific needs of the aquatic sports, which are not compliant with the routine forecast of the public weather services. The needs relate in particuliar to the parameters wind speed and wind direction, which are normally neglected by the public services' forecast. And there is another problem: information for particularly difficult forecast regions is often required, notably those which are characterized by frequent occurrences of mesoscale phenomena (thermal circulation systems, dynamical effects of topography) thus reducing the quality of the forecasts. Moreover, we have to face the problem that the actualisation rate of the public weather forecast still does not yet correspond to the needs of the rather short - term decisions required by route planning. This leads to non - effective route planning or even to an endangering of life and material.

Another source of dissatisfaction lies in the interpretation of numerical products, which are normally offered by fax or on - line. The full content of information generally does not come to the sportsmens' knowledge due to their insufficiant state of training in synoptic meteorology. This is a problem caused by the aquatic sports itself resulting from the traditional training methods of the sailing schools. There is a general lack of training to put meteorological knowledge into practice. This is particuliarly important in the interpretation of weather charts.

The solution of the problems discussed above is to be provided by METEO - data, one of the greatest private weather services in Europe. They offer in the form of the recently founded *sailing & weather club* a Europe - wide meteorological coaching for aquatic sportsmen. An extensive weather consulting, which consists of substantial real-time weather informations tailored to the specific needs of aquatic sports, is made available to sailing and surfing sportsmen. The beneficiaries are leisure-time yachtsmen as well as participants of boat - races. This is made possible by the expert knowledge of the consultant meteorologist who is personally an aquatic sportsmen, as well as by the modern way of information transmission. The club meteorologist sends the wind and weather forecast as a text file to the user at the sports club or directly to the skipper on board. The message is received by means of a mobile, universal transmitter/receiver, that combines the properties of a GSM - telephone, Fax machine and notebook with internet application. Thus for the first time the overall request for a real - time meteorological consulting becomes reality.

METEO - data also offers meteorological training of aquatic sportsmen. Courses in meteorology for the purposes of sailing and surfing are planned. Special attention will be paid to the participants' ability for putting meteorological knowledge into practice. Furthermore, the participants in the course shall learn, how to make use of the diverse offers of weather information nowadays and how to handle the corresponding technical infra - structure.

AN ASSESSMENT OF RECENTLY INTRODUCED FORECASTS FOR AGRICULTURE & TOURISM

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ABSTRACT

The Meteorological Department in Jersey provides a Meteorological and Climatological service for aviation, government departments, shipping, the media and the general public in the Channel Islands.

Following a number of customer surveys, carried out in 1995, the results of which were presented at ECAM'95, a number of new services were introduced.

These included:

1. a six day forecast, mainly for farmers, issued daily
2. a "Holiday Weather Forecast", issued early each morning to hotels.

The paper will give details of these new services, customer reaction to them and measurements of their accuracy.

SEVERE WEATHER IN MEDITERRANEAN PORTS

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ABSTRACT

The U.S. Navy operates throughout the world. Ship captains often find themselves in new locations fairly regularly with experience providing a cornerstone of operational safety, whether in peacetime or time of conflict. The complex land-sea distribution and local thermal effects and oceanographic features of the Mediterranean Sea region have strong local influences on the synoptic scale circulation patterns. The interactions between local and synoptic scale forcing produce wind systems that provide a challenge for even the most experienced ship captains. A large number of well known "local" wind events, including the Levante, Mistral, Bora and Sirocco, yield complicated variability in weather conditions.

Many of the local winds are characterized by rapid onset and cessation, as well as significant spatial variations. These rapid spatial and temporal variations of coastal gale force winds can cause an unaware or unprepared ship to drag anchor or the generation of hazardous sea states that can pose a danger to small boats ferrying personnel between anchored ships and landings. The synoptic scale conditions depicted on weather charts may not reveal the causes and potential effects of local forcing, which can vary dramatically over small distances.

Because of the irregular coastline and numerous islands in the Mediterranean, swell can be refracted around barriers and can come from directions which vary widely from those of the wind and wind waves. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for close maneuvering of ships/boats of different lengths and response characteristics. Moderate to heavy swell may propagate outward in advance of a storm, causing uncomfortable and sometimes dangerous conditions, especially during

tending, refueling and boating operations. In addition, restrictions to visibility and thunderstorms can also be hazardous to operations in and around port areas.

The U.S. Navy recognized such environmental factors were concerns to many ship captains and asked the Naval Research Laboratory Marine Meteorology Division, Monterey, California to evaluate the severe weather suitability of 55 Mediterranean ports and document the results. The analyses provide decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the vicinity of a particular port.

Severe weather studies of the 55 ports of interest (see Table 1) were disseminated under the general title, "Severe Weather Guide Mediterranean Ports," each with its own port name and sequence number. Because of interest in the compilation of all the port studies as a ready-reference guide, the 55 port studies were placed in electronic media and adapted to CD-ROM disc and also as a single hard copy handbook.

The purpose of this paper is to describe the development strategy of the individual port studies, provide insight into the details of the presentation of the information in hard copy and electronic form, and suggest some improvements. In addition, an example will be shown of how high resolution atmospheric modeling can be used to gain insight of extreme wind events for individual port locations.

Table 1. 55 Mediterranean ports evaluated, by study number and port name.

NO.	PORT	NO.	PORT
1	GAETA, ITALY	28	PORTO TORRES, ITALY
2	NAPLES, ITALY	29	PALERMO, ITALY
3	CATANIA, ITALY	30	MESSINA, ITALY
4	AUGUSTA BAY, ITALY	31	TAORMINA, ITALY
5	CAGLIARI, ITALY	32	TARANTO, ITALY
6	LA MADDALENA, ITALY	33	TANGIER, MOROCCO
7	MARSEILLE, FRANCE	34	BENIDORM, SPAIN
8	TOULON, FRANCE	35	ROTA, SPAIN
9	VILLEFRANCHE, FRANCE	36	LIMASSOL, CYPRUS
10	MALAGA, SPAIN	37	LARNACA, CYPRUS
11	NICE, FRANCE	38	ALEXANDRIA, EGYPT
12	CANNES, FRANCE	39	PORT SAID, EGYPT
13	MONACO	40	BIZERTE, TUNISIA
14	ASHDOD, ISRAEL	41	TUNIS, TUNISIA
15	HAIFA, ISRAEL	42	SOUSSE, TUNISIA
16	BARCELONA, SPAIN	43	SFAX, TUNISIA
17	PALMA, SPAIN	44	SOUDA BAY, CRETE
18	IBIZA, SPAIN	45	PIRAEUS, GREECE
19	POLLENSA BAY, SPAIN	46	KALAMATA, GREECE
20	LIVORNO, ITALY	47	KERKIRA(CORFU), GREECE
21	LA SPEZIA, ITALY	48	KITHIRA, GREECE
22	VENICE, ITALY	49	THESSALONIKI, GREECE
23	TRIESTE, ITALY	50	VALLETTA, MALTA
24	CARTAGENA, SPAIN	51	ISTANBUL, TURKEY
25	VALENCIA, SPAIN	52	IZMIR, TURKEY
26	SAN REMO, ITALY	53	MERSIN, TURKEY
27	GENOA, ITALY	54	ISKENDERUN, TURKEY
		55	ANTALYA, TURKEY

AUTOMATION OF AVIATION FORECASTS - AUTO-TAF AND GRID-POINT MOS

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1. INTRODUCTION

In close cooperation with the German Weather Service Meteo Service has developed a comprehensive software system aiming at the automation of aviation weather forecasts. It was implemented in 1996 and consists of the components Auto-TAF and Grid-Point MOS (GP-MOS). Auto-TAF produces three outputs: TAF-guidance, encoded TAF and Auto-GAFOR. GP-MOS produces probabilities of significant weather conditions at grid points. Auto-TAF is outlined below in section 2, with the exception of the Auto-GAFOR component, which is described by Richter (1997). GP-MOS is presented in section 3. Operational forecast examples of these and other statistical weather forecasting systems can be found in Haalman et. al. (1997).

2. AUTO-TAF

2.1 TAF-Guidance

TAF-guidances are MOS forecasts for a special set of elements to be forecast in TAFs and GAFORs. The MOS regression equations were derived separately for four seasons from data of about 100 stations collected for more than four successive years. The data were obtained from the European Model (EM, developed by the German Weather Service, horizontal resolution about 55 km) and from observations (SYNOP). Table 1 shows the operational scheme of TAF-guidance production.

Predictands are the elements to be forecast in the TAF-guidance. Predictors are the independent variables used as input. The regression algorithm selects and weightens the predictors in order to combine them in an optimum way.

Issue hh.mm	Last obs	EM-run	Valid Time TAF	Valid Time GAFOR
00.13	23	12	01-10	
01.30	00	12		03-12
03.13	02	12	04-13	
04.41	04	12	12-06	06-15
06.13	05	12	07-16	
07.30	07	00		09-18
09.13	08	00	10-19	
10.41	10	00	18-12	12-21
12.13	11	00	13-22	
13.30	13	00		15-00
15.13	14	00	16-01	
16.41	16	00	00-18	
18.13	17	00	19-04	
21.13	20	12	22-07	
22.41	22	12	06-00	

Table 1: TAF-guidance: Operational scheme

The TAF-guidance predictand set contains the categorical and probabilistic information needed for the automatic generation of TAFs and GAFORs. Much care has been given to the proper definition of the predictands, in order to meet the special TAF and GAFOR needs and to make the encoding as easy as possible. The predictors were described by Knüpffer (1995). Many of them are transformed and defined according to synoptical reasoning. The predictors are subject to steady improvement.

2.2 MOS Equations and Their Synoptical Interpretation

The regression algorithm has been optimized with the aim to minimize the RMSE of the predictands on independent data. This optimization is based on results from research on statistical overfitting, details of which can be found in Knüpffer (1996).

Tables 2a and 2b show examples of MOS equations for the predictands "Probability of the occurence of thunderstorms in the ww code" (P(Ths)) in summer and "Maximum gust of the recent 3 hours" (FX3) in spring. Both equations were derived for forecasts issued at 10.41z and valid at the airport of Frankfurt/Main at 18z. The way in which the prognostic information present at issue time is combined into a forecast of these convective phenomena will be illustrated by an example.

St=10637 Issue=06z Lead Time=+012					
EM-Run=00z Predictand=P(Ths) Summer					
R(Pd)	R(Res)	Name	dRVI	Co	Wgt
0.37	0.37	ThsKoH	13.2	2.48	32
0.36	0.30	ThsSM	7.2	4.76	30
0.28	0.18	StF(ww8)	1.5	0.22	19
0.29	0.15	Rot1/FF1	0.5	0.10	19
		Constant		-0.6	
#Cases= 422 #PotPr=165					
MV(Pd)= 3.4 RV = 27 RMSE =11.5					
SD(Pd)=13.5 E(RVI)= 21 E(RMSI)=12.0					

Table 2a: MOS Equation for Probability of Thunderstorm

St=10637 Issue=06z Lead Time=+012					
EM-Run=00z Predictand=FX3 Spring					
R(Pd)	R(Res)	Name	dRVI	Co	Wgt
0.73	0.73	StF(FF)	53.2	1.96	70
-0.28	-0.19	ThWAdv85	1.5	-0.10	-16
0.35	0.18	ThsSL	1.3	0.59	14
		Constant		-0.7	
#Cases= 379 #PotPr=156					
MV(Pd)=14.2 RV = 58 RMSE = 5.7					
SD(Pd)= 8.8 E(RVI)= 55 E(RMSI)= 5.9					

Table 2b: MOS Equation for Maximum Gust

Out of a set of about 150 potential predictors the regression algorithm first selects the predictor with the highest linear correlation with the predictand. For P(Ths) this will be the Ko-Index, defined between 700 and 300 hPa (ThsKoH) with a correlation coefficient of R(Pd) = 0.37. Next, the regression algorithm selects the predictor with the highest correlation with the residual (i.e. the error) of the one-predictor equation. This is the S-index defined between 850 and 500 hPa (ThsSM). This thunderstorm index obviously contains prognostic information which is independent from that of the first one. This can be seen from the fact that the correlation of this predictor with the residual (R(Res)) is only a little smaller than its correlation with the predictand. The next predictor included in the regression equation is the statistical forecast of (any) convective precipitation (StF(ww8)), which has been calculated before and is used as a potential predictor here. Finally, the rotor of the geopotential height field at 1000 hPa, normalized by the wind speed at 1000 hPa (Rot1/FF1), has been selected by means of the regression algorithm. The rotor is defined as Laplacian applied to the 1000 hPa geopotential height field.

The columns behind the predictor names show the expected reduction of variance on independent data (dRVI), which is due to the inclusion of the predictor. The regression algorithm stops after the inclusion of the fourth predictor, because the correlation of the fifth predictor with the residual of the four-predictor equation is lower than the critical correlation. The latter value is a function of the number of cases and the number of potential predictors. The second column behind the predictor names shows the regression coefficients of the final regression equation. The regression equation for forecasting the probability of a thunderstorm is:

$$P(Ths) = -0.6 + 2.48*ThsKoH + 4.76*ThsSM + 0.22*StF(ww8) + 0.10*Rot1/FF1$$

and can be interpreted as follows:

+0.22*StF(ww8): About every fifth convective precipitation event (ww8) must be expected to be thundery.
+2.48*ThsKoH + 4.76*ThsSM: If the thunderstorm indices (only positive values are possible) suggest that the atmosphere is likely to create thunderstorms, this general expectance of thunderstorms will be further increased.
+0.10*Rot1/FF1: Finally, the result of the combination of the first three predictors is corrected by the cyclonality of the 1000-hPa field: anticyclonic isobar patterns will reduce P(Ths), while cyclonic patterns will increase it.

The weights listed in the last column illustrate the importance of each individual predictor in the regression equation. Weights are regression coefficients normalized by their standard deviation. The overall sum of the absolute values of all predictor weights is 100 per cent, the sign is that of the regression coefficient. Weights are helpful for the synoptic interpretation of a regression equation: As can be seen, 62 per cent of the final forecast for P(Ths) results from combining the two thunderstorm indices having nearly the same weights (although not equal coefficients) of 32 and 30 per cent. The remaining 38 per cent are shared by the last two predictors. Summary statistics of this equation can be found in the lower part of the table. They indicate that the reduction of variance in the equation for the development sample (RV) is 27 per cent, the expected reduction of variance on independent data E(RVI)) being only 21 per cent.

The regression equation for FX3 can be interpreted synoptically in an analogous way: The best first guess for FX3 is to multiply the statistical forecast for FF (StF(FF)) by a factor of about 2. The following predictors can be interpreted as corrections of this simple approach: If the advection of wet bulb temperature at 850 hPa (ThWAdv85) is positive (typical warm-front situation) gusts will be suppressed, if it is negative (typical cold-front situation), stronger gusts will be expected. Finally, if the S-Index, defined between 925 and 700 hPa (ThsSL), indicates the readiness of the lower troposphere for convective activity, statistics will add further knots to the forecast.

2.3 *Encoded TAF*

The encoding of the TAF-Guidance into a TAF complying with ICAO and WMO regulations is controlled by two conflicting criteria: a) The loss of relevant information due to the encoding must be minimized.
b) The code should be as short as possible.
A bonus/penalty system controls the optimization in the process of Auto-TAF generation which is described by Knüpffer (1997). There also results of a first verification based on the TAF verification scheme of the German Weather Service (Balzer, 1994) are discussed.

3. GRID-POINT MOS

MOS equations for the probability of the occurence of isolated, occasional and frequent thunderstorms are derived for grid points based on the SYNOP observations in a certain influence radius around the grid points. In 1997 GP-MOS is continued on the basis of lightning detection observations. They are continuously available in space and time and allow for the development of a nowcasting component: Forecasts can be issued at any time, the resolution in time being 15 minutes, in space 27 km. Special extrapolation predictors are being established, including recent-minute observations and the environmental conditions prevailing around the starting point of the trajectory of the 700-hPa model wind.

4. OUTLOOK

The Auto-TAF and GP-MOS systems have a high potential for automating the production of aviation forecasts. TAF-guidance and Auto-GAFOR have been well received by the forecasting community. The weak point of the whole system is the TAF encoding algorithm, which, however, can undoubtedly be improved considerably in the near future. Attempts for improving the TAF-guidance will be directed towards the extended use of conditional climatologies of the predictands in dependence of predictor values. This will help to improve the capability of the linear regression algorithm to consider non-linear facts. The inclusion of the output of a boundary layer model which produces categorical forecasts of the elements needed in Auto-TAFs would be desirable. GP-MOS is a starting effort for the automation of the Low-Level-SWC. Other elements like gusts, low ceiling and obstructions to visibility are to follow. International co-operation can help share development costs and make the results available to other weather services.

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5. REFERENCES

Balzer, K., 1994: TAF-Verifikation - Eine Dokumentation der Methodik, *DWD*, Potsdam

Haalman, D., Richter, B., Knüpffer, K, 1997: Automatic Real Time Aviation and MOS Forecasts, Preprint Volume: *3rd European Conference on Applications of Meteorology*, September 23-26, Lindau, this Volume

Knüpffer, K., 1995: Statistical Weather Forecasting Systems for the German Weather Service and the Swedish Meteorological and Hydrological Institute. Preprint Volume: *2nd European Conference on Applications of Meteorology*, September 25-29, Toulouse, 132-135

Knüpffer, K., 1996: Methodical and Predictability Aspects of MOS Systems. Preprint Volume: *13th Conference on Probability and Statistics in Atmospheric Sciences*. February 21-23, San Francisco, California, 190-197

Knüpffer, K., 1997: Automation of Aviation Forecasts - The Projects Auto-TAF and Auto-GAFOR. Preprint Volume: *Seventh Conference On Aviation, Range and Aerospace Meteorology*, February 2-7, Long Beach, California, 190-197, 444-449

Richter, B, 1997: Operational Use of MOS Forecasts in General Aviation (GAFOR), Preprint Volume: *3rd European Conference on Applications of Meteorology*, September 23-26, Lindau, this Volume

Hot Air Balloons
What do their Pilots expect from Meteorology ?
What can Meteorologists learn from Balloon Trajectories ?

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ABSTRACT

Balloonists expect a reasonable wind forecast for the next few hours to plan the best routing for their task. Over flat terrain this is usually being possible by local pilot balloon measurements and conventional nowcasts of the wind field. Over complex terrain however, the wind field may be determined by complicated local horizontal as well as vertical circulations in the spatial range from a hundred meters to several kilometers. As the flights usually take place in the early morning and evening hours the flow field should not be affected too much by convection. The complicated structure becomes evident by trajectories of individual balloons which show an unbelievable diversity. This implies in many cases a possibility to reach virtually every location wanted.

The wind information derived from balloon trajectories represents a unique database to study the deterministic and stochastic parts of the flow over complex terrain. It may be used to validate very high resolution models (horizontal resolution in the order of 100 m) and to answer the predictability problem of such scales of motion. It furthermore clearly shows that pilot balloon measurements or other vertical profiling methods at only one location are not sufficient at all to know about the flow structure within a valley segment.

The principal behavior of regular valley wind systems is well understood and described in the literature. Several field campaigns have been initiated to measure the energy balance or the mass flux balance of a well defined valley segment. In the more recent years high resolution numerical models are used to simulate the wind field over complex terrain. The verification of such a wind field is a difficult task since no 3D high resolution data sets are available. Balloon trajectories allow the computation of such a 3D wind field data set (vertical distribution of the horizontal wind field). On the one hand this data may serve as a simulation and verification set for high resolution numerical prediction models on the other hand meteorologists learn a lot about the large diversity of the wind field over complex terrain. This will finally help to improve the quality of wind forecasts over complex terrain and finally to increase the confidence of balloonists in the meteorologists work.

Operational (SYNOP, RASO) and advanced measurement techniques (e.g. SODAR, wind profiler) allow for a point value or a vertical (1D) 'pinprick' through the atmosphere. In cases of a complex terrain the question of the representativeness of these measurements arises. From the technical and funding point of view it is not possible to install these measurements sites on an adequate dense network (smaller than 1km).

The investigation area covers a valley segment around Kirchberg/Tyrol. During a weekly competition about 30 hot air balloons are distributed in the valley volume at the same time. With photogrammetrical methods (see below) the trajectories of the balloons are calculated.

The results presented (Fig. a,b) are for the 22 Sept. 1996 in the late afternoon. The meteorological characteristic was marked by a weak foehn situation over Kirchberg during the day. In the late afternoon the foehn broke down and the southerly flow was replaced by an inflow of cooler air from the north. Due to this inflow and the specific valley geometry a stationary lee vortex developed and stayed for at least half an hour. A similar vortex has been observed two years earlier during the same hot air balloon competition. Hence the occurence of complicated flow patterns like vortices in some valley segments seem to be a common phenomenon, leading to severe problems, when making conclusions from just one observing point in that valley.

The main idea of the chosen practice is the method of „Spatial Intersection". One feature of photographs is, that the point P in nature, the focus point F and the image of the point (i.e. „image point") p in the photo must be on one straight line. If you are able to measure one point in two photos, you have two straight lines intersecting the point P.

So we took photos from three observation points 1-3 (see Fig. a) on the slopes of the valley. These points were chosen because of optimal intersection angles and visibleness of the balloons. Their coordinates in the Austrian coordinate system (X,Y,Z) has been measured by simple geodetic methods. Of the three rotation angles between the „camera coordinate system" (x_i,y_i,z_i) and the Austrian coordinate system two have been defined by levelling the plates of the photo tripods. So only the angle between the two x-axes was unknown. but well defined by measuring so called „pass points" (known XYZ-coordinates) in the photos.

We also know the „inner orientation" (i.e. focus length, coordinates of the principal point, distortion curves) of the cameras, measured and computed by the Institute of Photogrammetry and Remote Sensing, Technical University of Vienna. The cameras were Nikon amateur cameras with 24 mm lenses.

The measurement of the balloons, pass points (e.g. church, mountain peaks), and so called „transformation points" (i.e. points spawning a large part of the area of the photo) has been made on a PC with a digitizer out of 20x30cm hardcopies.

All the above defined data was then handled by the photogrammetric bundle triangulation program ORIENT, developed by H. Kager, Institute of Photogrammetry and Remote Sensing, Technical University of Vienna. With this program the above explained spatial intersection of the balloons has been computed. The results were afterwards depicted by a HPGL-graphic interface.

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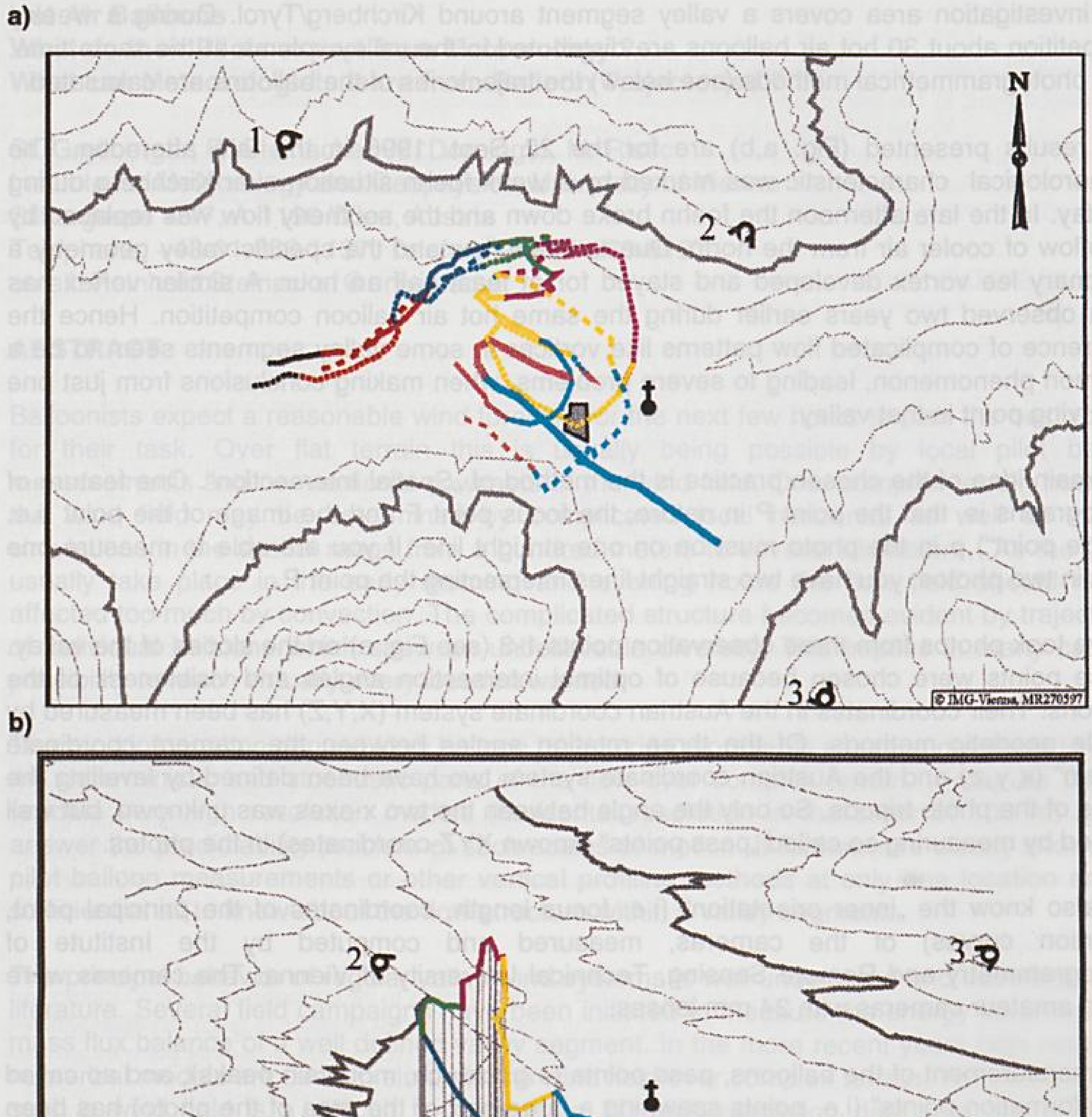

Fig. a,b: Plot of balloon trajectories for 22 Sept. 1996, ~ 1700 LCT in the area of Kirchberg/Tyrol. For geographical orientation see position of church at Kirchberg and photo observation points. Fig. a shows a selection of balloon trajectories observed from satellite perspective. The structure of the vortex is shown by this selection. Fig. b shows an individual balloon trajectory (observed from a bird's perspective) forced by the vortex nearby the starting area.

VERIFICATION OF ROAD WEATHER FORECASTS IN THE WINTER OF 1995/96

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1. Introduction

Germany's road weather information system, SWIS (Strassenzustands- und Wetter-informationssystem), is regarded as an additional tool in order to improve the efficiency of winter road maintenance. The aim of Germany's winter road maintenance is to prevent ice formation (e.g. salting before rime formation) or to keep the time during which a road section is slippery as short as possible (e.g. in the case of snowfall).

Road weather forecasts are considered to play a key role in this information system. The Deutscher Wetterdienst, as a partner in the SWIS-project, issues a set of different road weather forecast reports. One of these reports is the so-called detailed area forecast.

130 forecast areas have been defined for Germany. Forecast areas are climatic regions (based upon mean precipitation amounts, mean air temperature) sub-divided by 200 metre-intervals. For each of the forecast areas a 27-hour-forecast is produced daily at 9 UTC. The forecast is based upon a model guidance (usually "Deutschland Modell") and may be modified by the forecasters. The forecast is valid from 12 UTC of the actual day until 12 UTC of the following day and includes forecast time steps in increments of 3 hours. The following parameters are specified: cloudiness, precipitation, wind, air temperature and, as a result of the calculations of an energy balance model (Jacobs and Raatz, 1996), road-surface temperature and road conditions.

The detailed area forecasts represent one of the first forecast products of the Deutscher Wetterdienst, which are characterized by a very high resolution in space and time. It is the purpose of this study to verify for the very first time the quality of such a product.

2. Verification Procedure

51 forecast areas in western and southern Germany could be chosen for this verification study. Daily data of the winter season 1995/96 (7.11.95-31.3.1996) was available. Representative road weather monitoring stations were chosen for the verification of the parameters air temperature and road-surface temperature. Since cloudiness and precipitation are not measured at these sites additional representative synoptic stations had to be considered. The most interesting parameter, road conditions, however, cannot be verified, because it cannot be measured properly by the sensors currently available (Badelt, 1996), and because actions taken by the winter road maintenance as well as the influence of the traffic alter the road conditions significantly. Each of the forecasts contained in the detailed area forecast has been verified, i.e. we are considering a mixture of forecast times ranging from 3 up to 27 hours.

In the case of discrete predictands (e.g. road-surface temperature above or below freezing level, and precipitation yes/no) we have used the contingency table in order to define BIAS and True Skill Statistic (TSS). The BIAS is simply the ratio of the number of "yes" forecasts to the number of "yes" observations. A BIAS greater than one indicates that the event was forecast more often than observed ("overforecasting"), a BIAS less than one indicates that the event was underforecast. As skill score we used the True Skill Statistic (TSS). Perfect forecasts receive a score of one, climatic random forecasts (i.e. random forecasts at least considering climatic information) receive a score of zero.

In the case of continuous predictands (e.g. road-surface temperature and air temperature) we used BIAS and root mean square error (RMSE) to describe the forecast quality. BIAS describes in this case the systematic error (e.g. too cold or too warm; Bias=0 no systematic error). RMSE is interpretable as a typical error magnitude.

3. Results

In this study we will present the results of the verification for the two parameters road-surface temperature and precipitation only. However, these two parameters are the most important parameters since they determine to a large extent the road condition.

3.1 road surface temperature

First let us consider the forecast whether the road-surface temperature will be below or above the freezing level regardless of the magnitude (Table 1). During the winter 1995/96 there was a probability of 39% for the occurrence of road-surface temperatures to dip below freezing level in the lowest altitude interval, increasing to 57% in the interval 600-800 metres. The forecasts achieved a TSS of about 70% which do not differ much with altitude. On the other hand, when investigating the forecast values of road-surface temperature we notice that the RMSE seem to increase with altitude, as well as the BIAS. Thus, forecasters tend to have more difficulties in predicting road-surface temperatures for the upper regions than for the lowlands.

The BIAS is fairly small, and negative values indicate that road-surface temperatures were predicted slightly too high. This is an interesting result, because so far it has been assumed that forecasters would tend to forecast temperatures generally lower than observed (pessimistic, but less risky forecast).

When we consider the RMSE over the 27 hour forecast period,i.e. its daily variation, we find that the RMSE for the next 3 to 6 hours, respectively, are larger than the RMSE during night-time, whereas towards the end of the forecast period they are highest. This is consistent with the general knowledge that RMSE become larger as forecast time increases. However, it is interesting to note, that during night-time RMSE are smallest. We believe that solar radiation and variability of cloudiness (difficult to predict) are mainly responsible for the fairly large RMSE during daytime hours. As a comparison the RMSE for air temperature are shown as well. The results are similar, however RMSE is generally lower.

3.2 precipitation

To begin with we will verify the forecasts on the occurrence of any pecipitation event regardless of its liquid or solid phase (Table 2). During the winter 1995/96 the probability of the occurrence of a precipitation event increased from 31 to 40 % with altitude. The TSS achieved by the forecaster increases with altitude, but decreases again for the highest altitude. Values of TSS range between 38 and 41%. BIAS varies little with altitude, but overall the results indicate that the forecasters did underestimate the occurrence of precipitation.

We will now investigate the cases when there was precipitation forecast and actually observed (only 17% of all forecasts issued). For this small sample we ask if the phase of the precipitation was forecast correctly. We find that regardless of altitude the liquid phase was less frequently forecast than necessary. On the other hand, the occurrence of snow was too often predicted.

4. Discussion and Outlook

It should be emphazised, that this verification study investigated for the first time the quality of a forecast product of the Deutscher Wetterdienst, a product which is characterized by a high resolution in space and time. Hence, this verification looks at the meso-β /meso-γ domain of atmospheric phenomena. The statistical measures used in this study should be regarded under that respect. We believe that the results are satisfying and confirm that it is possible to issue forecasts with such high resolutions. Customers are e.g. highly interested in knowing the beginning and end of a precipitation event in a still finer resolution of time. This information cannot be provided by the detailed area forecasts, but could be made available by nowcasting products.

Badelt, H. 1996: Praxisgerechte Anforderungen an Glättemeldeanlagen (GMA). Abschlußbericht. Bundesanstalt für Straßenwesen, Außenstelle Berlin.
Jacobs, W. and W. Raatz, 1996: Forecasting road-surface temperatures for different site characteristics. Meteorol. Appl. 3, 243-256.

Table 1: road-surface temperature below the freezing level (Yes/No)

altitude interval	probability of occurrence	TSS
0-200 m	39 %	70 %
200-400 m	49 %	71 %
400-600 m	55 %	70 %
600-800 m	57 %	69 %

Table 2: occurrence of precipitation (Yes/No)

altitude interval	probability of occurrence	TSS	BIAS
0-200 m	31 %	38 %	0.77
200-400 m	32 %	39 %	0.74
400-600 m	35 %	43 %	0.78
600-800 m	39 %	41 %	0.76

THE COMMERCIAL WEATHER SERVICES TO PUBLIC THROUGH ELECTRONIC MEDIA IN FINLAND

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ABSTRACT

During recent years new media has been introduced for general public. Among these new media are Internet and especially the World Wide Web (WWW). It has spread all over the world and now it has even huge commercial expectations. The future will show if it becomes more than just a new possibility.

Graphical real time weather information is very suitable for WWW. Newspapers have limitations in freshness and TV has limitation in terms of schedules and locality. When digital means of payment become secure and well established in WWW the real time weather information will become a natural part of life of those people having access to WWW.

The future will bring out new techniques applying cable TV network and cable modems or wireless Data Broadcasting. In this "SkyWay" service (the name of Data Broadcasting in Finland) data is transmitted to customers in the field of blanking interval of a TV signal. Users need special decoder for this data and a PC. Cable modem technique is able to transfer much more data than Data Broadcasting system but it is not yet an operational service in Finland.

The traditional way using modem to modem connection between customers and service provider will still maintain it's position for a while at least. The modem connections are possible with normal cable telephone network or with wireless GSM (Global System for Mobile Communications) mobile telephones.

Text messages can be transmitted directly to customers using digital mobile phones. This media has limitations because only short messages are possible. Because there are mobile phones for so many people now and more in the future this will be the most natural way in transmitting the weather information. Standard short text forecasts, observations and warning messages are the most suitable types of information.

Finnish Meteorological Institute has been an information provider and has developed customer products to these new media. WWW has been used in transmitting both text based information and graphics for clients. A special PC software called "Weather Window" has been used to animate radar and satellite pictures as well as other data for different end users. The data has been transmitted by Data Broadcasting, by Internet and by modem to modem connections.

The digital mobile telephones (using GSM standard) has been used to serve customers in normal telephone services and by sending text messages. The users have access to real time observation data base and to some forecast products.

In the future personal mobile communicators (combination of a PC and mobile phone) may have an important role in peoples live and it will also be a very convenient way to get access to weather service products in real time. Also new technology which combines TV and Internet may have a great impact on the market.

Introduction

Electronic media is developing very fast at present and it is not even reasonable to try to make a printed update about the recent developments. Another reason not to do this is that there are country to country differences in infrastructure. Opportunities that are relevant in one country are not in another. Therefore this paper is just giving some highlights about the activities at FMI during the past few years and some future prospects.

Some areas of telecommunication are well developed in Finland. Mobile phones are very common and almost every third person has one. Not all of those phones are digital yet but the amount of digital phones will definitely increase. The same kind of progress will meet also the rest of Europe. The internet (specially WWW) is also spreading out of academic world to become a new of media for common people. In this area Finland is also one of the leading countries in the world and it gives FMI a good opportunity to test even the commercial possibilities in Internet. At the moment the internet is not commercially important but the future expectations are high.

The new intercast technology allows PC users to watch TV and simultaneously receive broadcast web pages related to that television program. The Intercast medium provides consumers with exciting multimedia-enriched information that is broadcast along with regular programming signals. This is one of future technologies that also give opportunities for the community. The mobile satellite communication technology will also create both new opportunities and challenges.

WWW based services

FMI has commercial WWW service for general public and for special customers. Telecom Finland is taking care of operative service for general public. The products that are available there are different satellite and radar pictures, forecasts of temperature zones and marine winds. This service has not yet been commercially important but we expect that it will change.

For special customers FMI has tailored own Web pages. The customers have longer contracts and they get access to their own pages by using their password. Some of these customer groups are local or nation wide radio channels, some newspapers and the organisers of out door festivals. This media is under rapid develeopment and FMI is introducing most new products by using it.

PC software "Weather Window"

The "Weather Window" PC software has been applied for visualisation of meteorological data for special customers and general public. The products available are animated radar and satellite pictures as well as marine wind forecasts and observations. Some general forecasts in text or graphical form are also available. The system is running on Windows 3.1 and Windows 95 and modem to modem connections as well as connections via an operator are possible.

The software is free for customers but the data costs. The user can copy the software from FMI home page. The users can then get access to the data at FMI using two commercial operators.

In the service for general public this software will be replaced by a new WWW based system near future. A WWW based system is more flexible and among other features animations are now easy to perform in Web.

Data Broadcasting

The technique has been used first in U.K. in mid 80´s by BBC. The service was called BBC Datacast. In Finland there has service since 1993 and FMI has been using this "SkyWay" service since 1995. Professional Data Broadcasting services exits at least in 9 European countries. Customers have been able to use this transmitting technique in association with Weather Window system. One of the shortcomings of this technique is that it is not interactive, the other one is the capacity of transmission.

FMI has no plans to use this technology further. The next generation digital TV is going to change the situation dramatically because the band width will be then much larger.

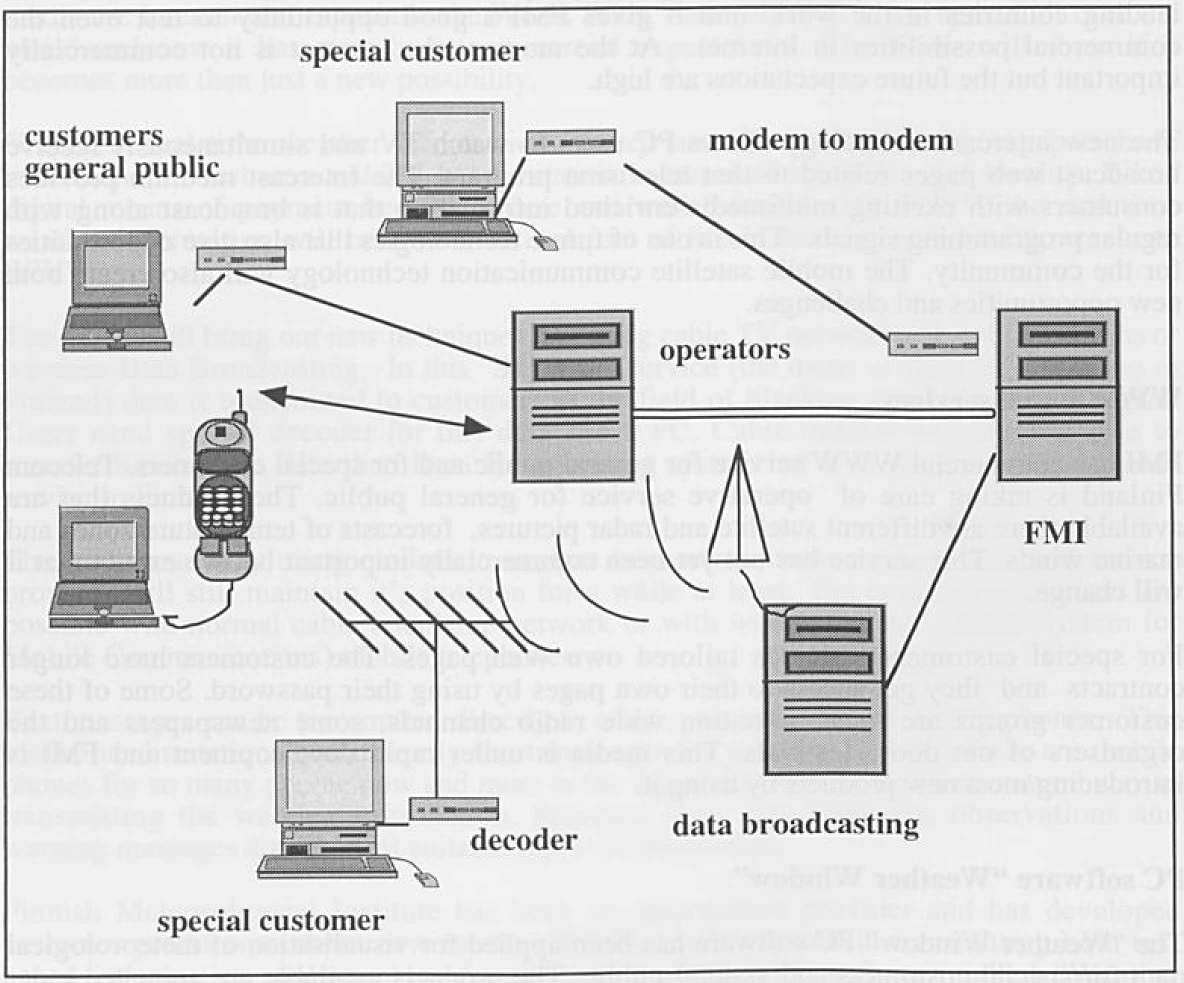

Figure 1. The system for transmitting weather information to "Weather Window" PC software.

GSM text messages

The text message service has been working now almost 2 years (Kilpinen 1995). The system includes at present real time observation from coastal and marine stations as well as 2 day wind forecasts for different areas of the Baltic Sea. We are now working on to get other surface observations and general forecasts into the system.

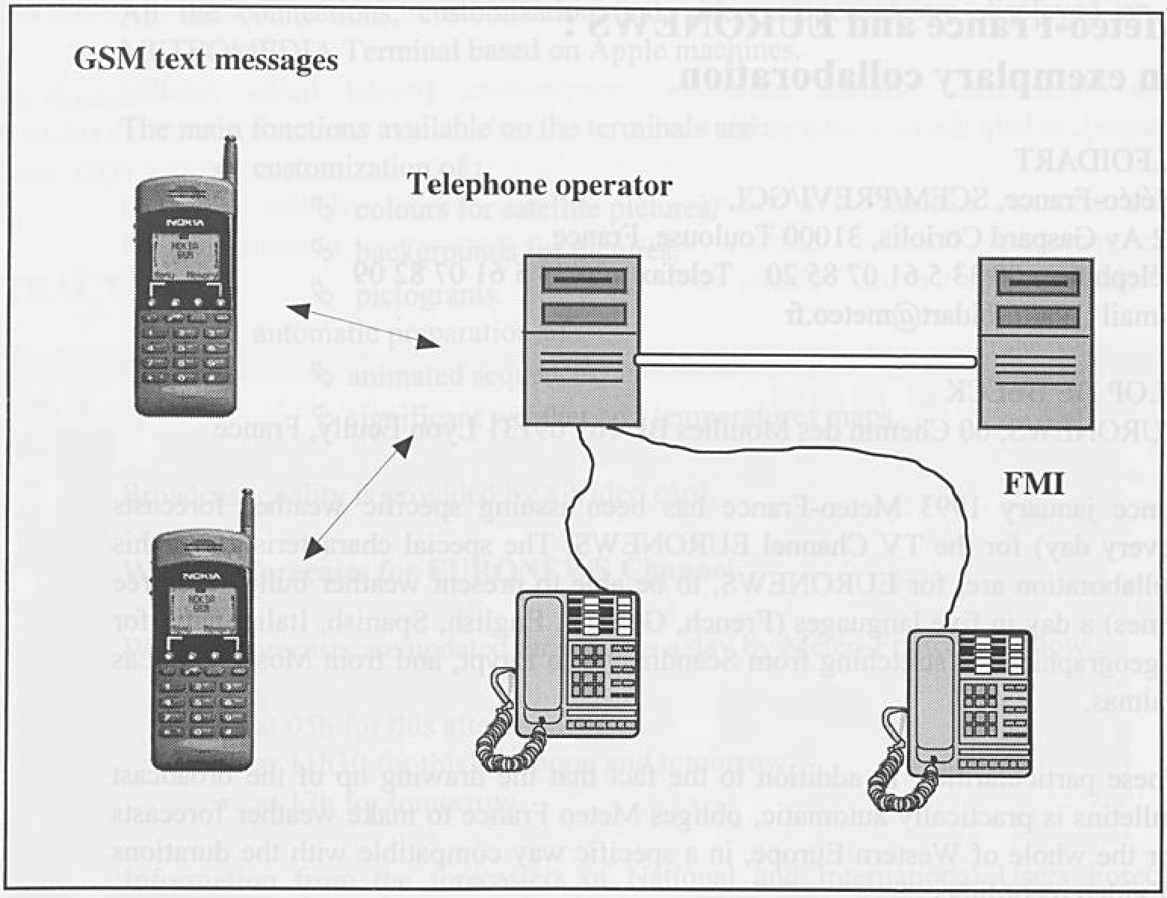

Figure 3. Automatic telephone and GSM text message service at FMI.

The message can include only 160 characters. Therefore only short messages or short tables are possible. The weather element information is stored in a data base system and GSM text messages and also graphics for Weather Window system. The same basic information can be heard also in voice telephone where the voice is generated automatically (Kilpinen et. al., 1996).

Conclusions

FMI will continue the work in advancing the application of new technology. The plan is to make the most of new applications to World Wide Web and mobile systems.

References

Kilpinen, J., Kukkonen, P., Kuoremäki, T., Niemelä, K., Nyfors, V., Pirinen, P., Winberg, L., 1996. Modernisation of Meteorological Information and Visualisation System at Finnish Meteorological Institute. 12th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, January 28 - February 2, 1996, Atlanta, Georgia, pp. 85-86.

Kilpinen, J., 1995. The development of a new operational database system at Finnish Meteorological Institute (FMI), Proceedings of Fourth Workshop on Meteorological Operational Systems, ECMWF, 13 - 17 November 1995, pp. 226 - 229.

Météo-France and EURONEWS : an exemplary collaboration

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Since january 1993 Meteo-France has been issuing specific weather forecasts (every day) for the TV Channel EURONEWS. The special characteristics of this collaboration are, for EURONEWS, to be able to present weather bulletins (three times) a day in five languages (French, German, English, Spanish, Italian) and for a geographic area stretching from Scandinavia to Egypt, and from Moscow to Las Palmas.

These particularities, in addition to the fact that the drawing up of the broadcast bulletins is practically automatic, obliges Meteo France to make weather forecasts for the whole of Western Europe, in a specific way compatible with the durations of video recordings.

EURONEWS

EURONEWS is the first News TV Channel, that broadcast (20 hours a day) all the worldwide news, with an european point of view (an important particularity of this channel). Programs are simultaneously available in five languages (as above). An important part is also broadcast in Arabic.
EURONEWS is distributed in 38 countries in Europe and also on the mediterranean area.
EURONEWS is the only channel dedicated as a vehicle of communication for an european identity.
First of all EURONEWS is a news channel, but the programs are also made to satisfy the viewer's focus of interest (economy, politics, social life, sciences, arts, culture, health, environment, fashion, travels, sports, leisure, weather forescast).

Météo-France and Météomédia System

Regardless of their structure, either text or image, all dedicated products for TV channels can be accessed on Météo-France data bases (DIAPASON in Toulouse).

All the connections, customization and video sequences are displayed on a METEOMEDIA Terminal based on Apple machines.

The main fonctions available on the terminals are :

- customization of :
  - ↳ colours for satellite pictures,
  - ↳ backgrounds for pictures,
  - ↳ pictograms.
- automatic preparation of :
  - ↳ animated sequences,
  - ↳ significant weather and temperatures maps.

Broadcast quality is provided by a Video card.

Weather forecasts for EURONEWS Channel

Weather forecasts are updated three times a day by Météo-France as follow :

- at 05h for this afternoon,
- at 11h30 for this afternoon and tomorrow,
- at 17h for tomorrow.

Information from the forecasters of National and International Users Forecast Department (SCEM/PREVI/Grands Comptes International in Toulouse) consist of:

- **Textual bulletins for four areas** (North East, North West, South West, South East of Europe).
  Each bulletin, by area, must have a determined length, so that the broadcast time is always about 17 seconds by area.
  The bulletins are sent to a translation company (Translatel in Paris) that makes the translations in four languages and records the sound files.
  At last the files are sent to Euronews.

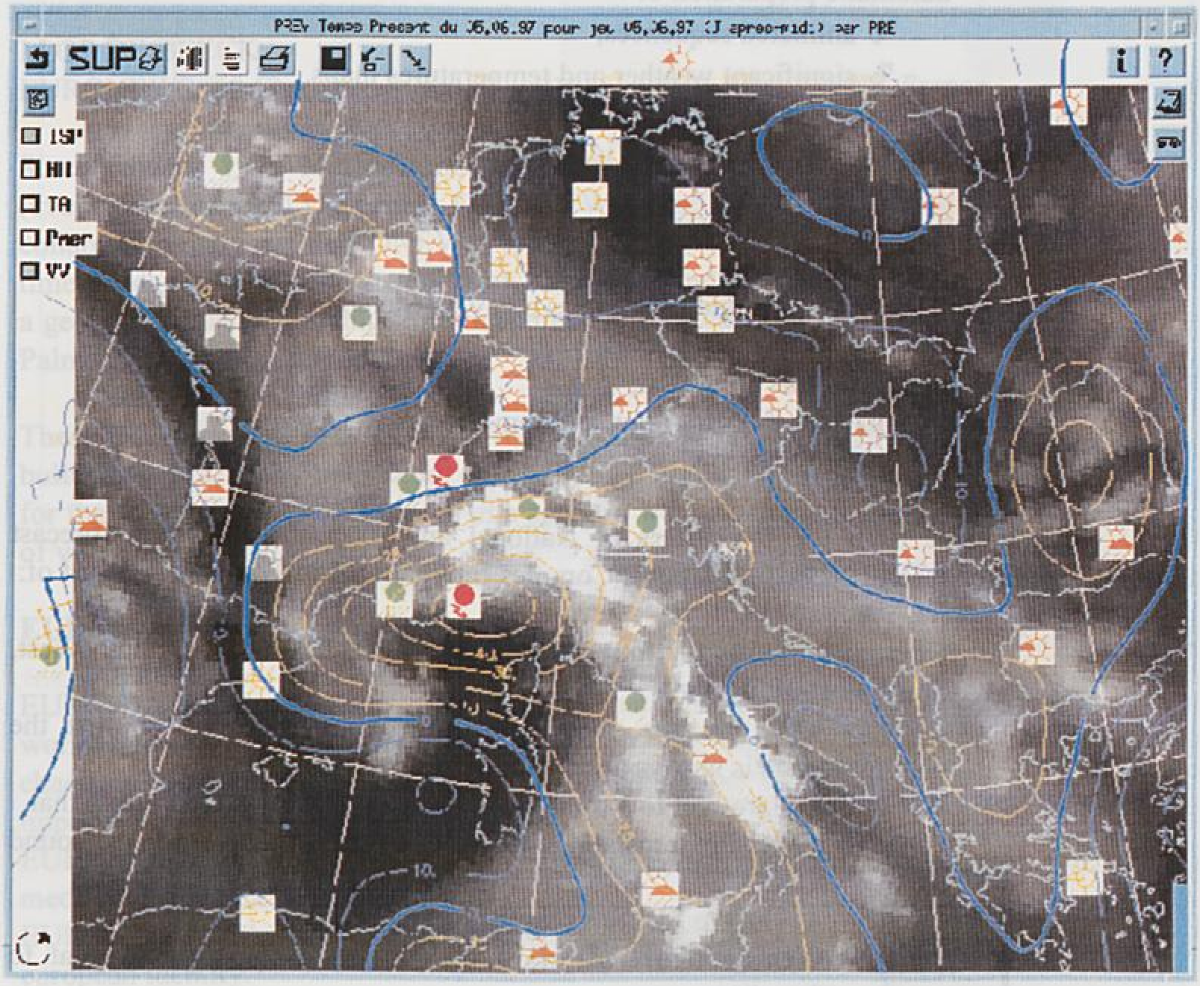
- **Weather Forecast data files** in the Meteomedia format to describe significant weather and temperatures for 69 European towns. The format allows the TV channel to display automatically the customized pictogram on the towns position.

To elaborate these forecasts the weather forecasters use a specific Météomedia Interface (under Synergie system).

17 Significant weather are available on the Meteomedia Interface (see left).

The Meteomedia interface authorizes superpositions (model fields, satellite images), to help the forecaster in his work.

Here after an example of a Meteomedia interface screen with the forecasted pictograms,the ''Forecast'' satellite picture (result from arpege numerical model simulation) and a Vertical Velocity field.



In fine, EURONEWS, on the one hand with the sound files from Translatel and on the other hand with the Meteomedia files, builds the video bulletin.

STRATEGY AND USE OF WEATHER INFORMATION ON TV

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ABSTRACT

I propose the development of the following theme:

"Communication and weather forecast".

In the history of communications weather forecasting has developed a lot, and has followed the great technological tendences (a little flashback in order to evoke the big changes in weather communications in the course of the centuries).

Nowadays weather forecasting makes a road into the audiovisual world: for its "sponsoring power", weather forecasting has become almost a complete broadcast on its own.

In every country civilization influences both the form and basis of the presentation. Nowadays, the communication's means, multimedia (the motorway of information) are in full development. The weather forecast puts itself at the very top of these projects. All these projects rely on the weather information.

Warnings, special short-term informations: the distribution of local forecasts is of considerable importance to the public.
Which means that the distribution (announcer, producer, etc...) of weather forecasting assumes great importance.

The close cooperation between media and science is absolutely necessary and the result will be better performance in the distribution of information to the public.

AIR QUALITY FORECASTING IN BERGEN, NORWAY

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ABSTRACT

The forecasters at DNMI in Bergen are predicting ambient air quality for Bergen 2 to 30 hours in advance in three categories. The air quality forecast is based on the statistical and actual values of NO_2 and PM10 and prognostic weather parameters from a NWP model. Knowledge about the state of the ground and the rate of pollution are of vital importance. The main task, however, is to predict subjectively the possibility of an inversion by anticipating the radiation conditions, and thereby the degree of air pollution.

The project «Air Quality in Bergen»

Part of the motivation for the project was the occasional occurrence of poor air quality during the winter seasons, causing serious problems to people with respiratory diseases. In addition the EU require monitoring of air quality in European cities. However, the primary objective of the project is to improve the quality of life for those susceptible to air pollution. By making the information available, they can plan and take precautions. As well, the project maps the areal and statistical distribution of the air pollution in the city. In this way, measures can be taken by the politicians and city planners in reducing the human exposure of air pollution.

The project is financed and administrated by the Municipality of Bergen and the Public Road Administration. The Norwegian Institute for Air Research (NILU) is providing the data for nitrogen dioxide (NO_2) and particulate matter (PM10) from three measuring stations in the city centre. The Norwegian Meteorological Institute (DNMI) is issuing daily air quality forecasts to local newspapers, radio stations and a local TV station. The media have given the project much attention in situations with heavy pollution.

The latest air quality forecast and hourly mean values of NO_2 and PM10 for the last three days are available on Internet (address: http://nettvik.no/raadhusplassen /thb/).

The sources of NO_2 and PM10

The main source of NO_2 is the car traffic. Nitric oxide (NO) in the exhaust reacts with ozone (O_3) forming nitrogen dioxide (NO_2). PM10 is defined as the total mass of particles of aerodynamic diameter less than 10 micro metre. In Bergen, as in other Scandinavian cities, we find a large amount of asphalt dust in PM10, due to extensive use of studded tires. About 10 000 tons of asphalt are rasped up in Bergen alone, and a significant part of this is whirled into the air as dust. In addition, there is a significant amount of soot due to imperfect combustion of diesel fuel and from the use of wood and oil in domestic heating.

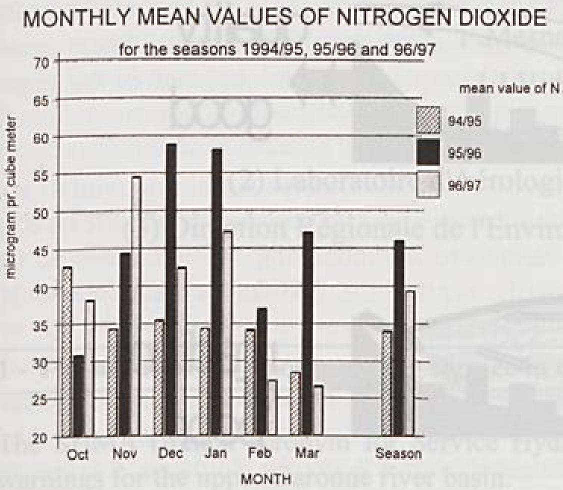
Classification of ambient air quality

Ambient air quality is classified into three categories according to the threshold levels given by the Norwegian Pollution Control Authority. The levels refer to the one hour average value for NO_2 and to a 24 hours average for PM10. Units are in micrograms per cube metre (μgm^{-3}). The categories are defined as follows: when $NO_2 < 100$ and/or $PM10 < 70$ then the air quality is good. Air quality is poor
when $NO_2 > 170$ and/or $PM10 > 120$, and medium (or moderate) for values in between.

Air quality forecasting and monitoring

For forecasting purposes it is important to know the statistical record of the air pollution in Bergen. The climate in Bergen is generally maritime and windy, but with a great variability from day to day and from season to season. The variability in the weather reflects the variability in the urban air pollution, shown in the three graphs below. In the winter season 1994/95 the air quality was generally good with only 9 days higher than the recommended levels for medium air quality. In 1995/96, however, we had 40 days with values higher than that level, and a seasonal average for NO_2 and PM10 of 46 and 24 μgm^{-3}, respectively. There were several days with recorded hourly mean values of PM10 and NO_2 between 200 and 300 μgm^{-3}.

Values for the street station were even higher (shown in figure 3). The season 1996/97 started with several pollution episodes, but from mid January the air quality was mainly good.



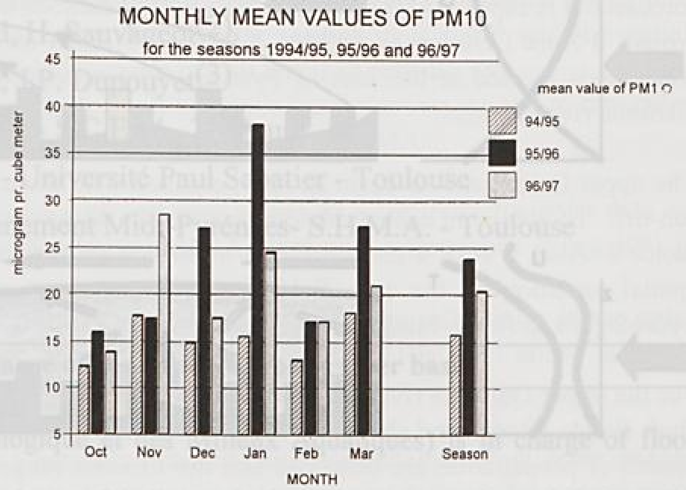
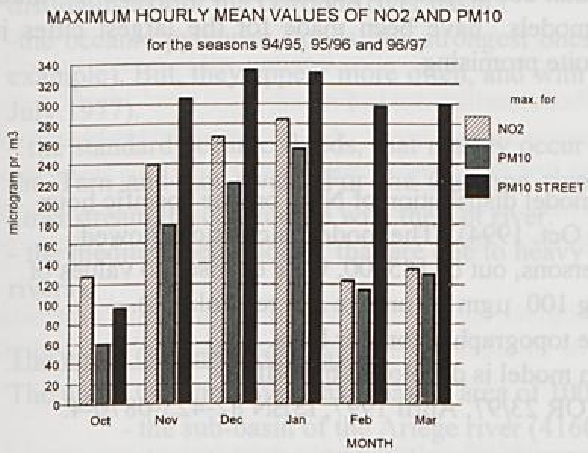


Figure 1 and 2. Monthly and seasonal averages of NO_2 and PM10 for the seasons 1994 to 1997.



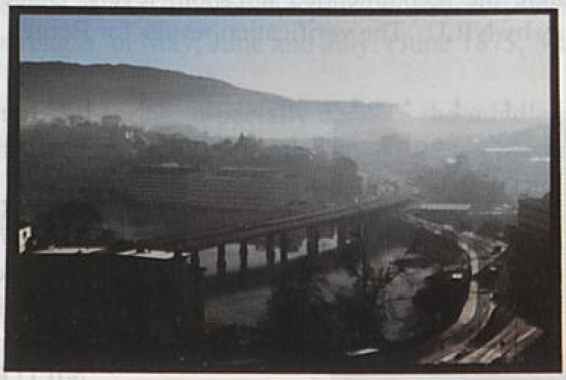


Figure 3. Maximum hourly mean values of NO_2 and PM10. Bars to the right (the darkest ones) are PM10 for the street station. Figure 4 is a photo of the air pollution in Bergen, January 1996.

To get a diagnostic picture of the actual air quality situation we have three sampling sites in the city centre giving hourly mean values of PM10 and NO_2. We have three measuring stations for temperature and wind. One is at the 2 m level in the city, one at the altitude of 35 m, and the third on a mountain top of about 600 m. The numerical weather prediction (NWP) model gives the prognostic values of the temperature and wind profile, cloudiness and precipitation. By combining the measurements, the statistics, the prognostic parameters and the experience gained by the meteorologists, we have developed a simple and fast method to predict air quality in Bergen up to 30 hours in advance. Knowledge about the state of the ground and the rate of pollution are of importance. Knowing e.g. the input profiles, the main task is to predict subjectively a possible formation of an inversion by anticipating the radiation conditions, and thereby the degree of pollution. The method is schematically drawn in figure 5. For instance, in the first situation the input profiles (sketched to the left) indicates windy weather and thermal instability, and the issued air quality forecast would become : «good air quality.» In the second (or lower) case the predicted wind profile shows light winds and an air mass with high thermal stability. An inversion is likely to form over the city. In midwinter the inversion sometimes becomes quite shallow. The city air is then trapped vertically by the inversion and horizontally by the mountains surrounding the city, resulting in heavy air pollution. In this case the forecast would sound: «poor air quality, persons with respiratory diseases are recommended to stay indoors until the air quality has improved.»

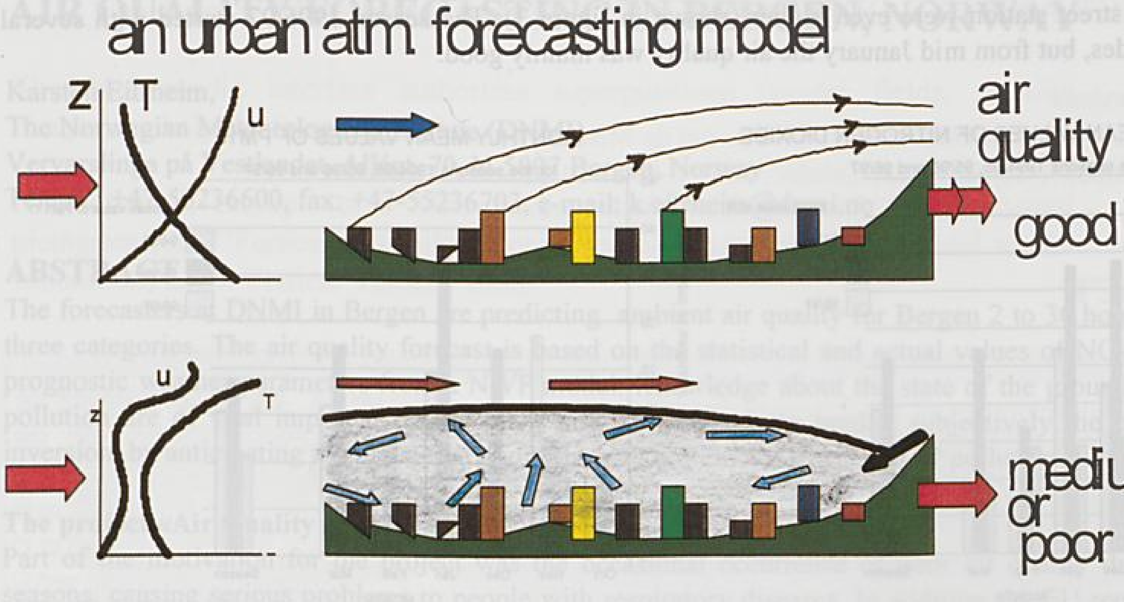


Figure 5. Schematic representation of the applied forecasting model for ambient air quality in Bergen.

In situations of medium or poor air quality it is anticipated that about half the population is exposed to values exceeding the recommended threshold levels. Dispersion models have been made for the largest cities in Norway by NILU. The verification results for Bergen look quite promising.

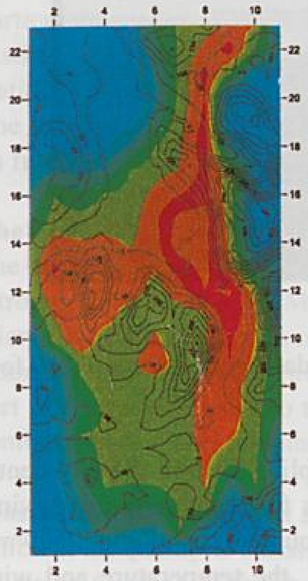


Figure 6. A model distribution of NO_2 on one specific hour in Bergen (20 Oct. 1994). The model calculation showed that 87600 persons, out of 185000, were exposed to values of NO_2 exceeding 100 μgm^{-3} (orange and red colours). Black lines are topographic contour lines.
The dispersion model is developed by NILU.
NILU Report OR 23/97, April 1997, ISBN 82-425-0870-4.

Continuation of the project

Measurements of some components of VOC (volatile organic compounds) have recently been included in the program. Monitoring and forecasting of ozone episodes in summer time may become part of the project as well. Emission of NO_x from a planned gas power station near Bergen may increase the amount of ozone at ground level, as the power station will be located near a crude oil terminal and a refinery. In sunny weather, favourable for formation of ozone by photochemical reaction, Bergen will usually be downstream these sources of VOC and NO_x.

By the end of this year DNMI will have implemented an operational NWP model with grid 10 km. By the application of this model, the option to buy a dispersion model from NILU, and by still applying the meteorological expertise in Bergen, we will be able to meet the future requirements from the public and our principals, the Municipality of Bergen and the Public Road Administration.

Flood forecasting and radar derived rainfall estimates

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1 - The needs of the flood warning service in charge of the upper Garonne river basin

The SHMA (french acronym for Service Hydrologique et des Milieux Aquatiques) is in charge of flood warnings for the upper Garonne river basin.

According to the meteorological conditions for which rain events occur, 3 types of flooding are generally distinguished for the Garonne river basin :
-the oceanic pyrenean floods, the strongest ones, can occur at any time of the year (in February 1952, for example). But, they appear more often, and with more strength, in May, June and July. (June 1875, May and July 1977).
- the standard oceanic floods, that mainly occur in winter and spring, especially concern the middle part of the Tarn and Lot rivers. For the Garonne river, such events concern only the part of the river situated downstream the confluence with the Lot river.
- the mediterranean floods, that are due to heavy rain on the eastern part of the basin (Tarn, Aveyron and Lot rivers).

<u>The upper Garonne river basin :</u>
The upper Garonne river basin has an area of 10000 km2, upstream Toulouse. It includes 3 main watersheds :
- the sub-basin of the Ariege river (4160 km2)
- the sub-basin of the Salat river (1570 km2)
- the sub-basin of the « upstrean Garonne » (2770 km2)

Limnimetric stations are installed at the outlet of these sub-basins and allow forecasts of run-off of the Garonne river at Toulouse. The intermediary watershed located between Toulouse and the bottom of the 3 already-named sub-basins is responsible for two particular difficulties :

- the importance of the intermediary watershed :

This intermediary watershed (15% of the upper Garonne river basin) give intermediary contributions quite variable according to the quantities of rain that fall on this area. The error due to a bad knowledge of rainfall amounts on this intermediary watershed can reach 0.5 meter for a level of 2 to 3 meters (corresponding to a 10-year return period). To overcome this source of errors, new methods of run-off forecasts for the intermediary part and for the downstrean part of the upper Garonne river basin have been developed and implemented.

These methods are based on a multi-model procedure. A forecast is performed for a given station, using several models taking into account different input data. Each model contributes to the final result, called weighted forecast, with a weight that is a function of errors registered for the near past. So, the forecast fitting process takes into account the errors due to bad estimates of rainfall amounts on the intermediary watershed. This approach is mainly based on a numerical process. A better knowledge of the rainfall event concerning the intermediary watershed would be more secure and more successfull.

- the monitoring of numerous small upstream watersheds

The monitoring of upstream watersheds is much more difficult. As their superficies range between 170 and 1000 km2, the knowledge of rain falling in these small watersheds is absolutely needed to perform run-off forecasts. It is especially the case for the warning stations of the sub-basins of Arreau-sur-Louron (170 km2), Arreau d'Aure (390 km2), le Mas d'Azil (215 km2) or Saint Béat sur Garonne (694 km2). These small watersheds located at the foot of Pyrenees range are responsible for strong floods observed in the upper Garonne river basin.

The upper Garonne river basin is, now, equiped with more than 30 automatic stations measuring rainfall and run-off. To obtain an acceptable coverage with raingauges, this number ought to be multiplied at least by a factor 3. And, if such a coverage is a minimum to perform rainfall-runoff modelling, uncertainties on the spatial variation of the rain field that will remain, can partly explain the difficulties encountered by hydrologists to fit the rainfall-runoff relationships.

For the upper Garonne river basin, difficulties are enhanced by the topography and rainfall pattern that cause flash floods. Slopes and shapes of basins allow a quick run-off of water and give sharp hydrograms. So, high speeds of propagation are observed and the forecast range cannot exceed 6 hours for Toulouse, 3 hours for the intermediary watersheds and 1 to 2 hours for small upstream watersheds. As the height of the rivers can grow by 0.5 to 1 meter per hour (and even more), it is clear that a good knowledge of the rainfall is needed.

For all the above-mentionned reasons, it has been considered that a complementary information on rain, the radar imagery, is essential.

In the field of flood warning, no operational attempt has yet been carried out in France.

Observation of rain by radar is particularily difficult in mountainous areas, due to possible problems of ground clutter (spurious echoes returned by the relief) and of blocking of the radar beam. An operating mode of radar with several elevation angles is a way to reduce ground clutter and blocking effects, but it generates other problems related to the higher height of the radar beam that lead to more frequent interceptions of the 0°Celsius isotherm.

So, in such a context, the use of radar imagery for hydrological applications need to develop correction algorithms, in particular for clutter suppression, correction of shielding effects and correction of the vertical profile of reflectivity (VPR).

To make some advances in the operational use of radar imagery for flood warning application, a cooperative project was started in 1995 by the Direction Régionale de l'Environnement Midi-Pyrénées, Météo-France and the Laboratoire d'Aérologie in the frame of GISELE (french acronym of Groupement Inter-organismes Scientifique pour l'Evaluation des Lames d'Eau).

The aim of the project is to test a real-time system devoted to runoff forecasts and flood warning for the upper Garonne river basin, using areal rainfall estimated by radar.

2 - The GISELE real time experimental system

This experimental system starts on the radar site where images of hourly rainfall amounts deduced from radar data are produced and finishes at the flood warning service where these images are used as an input for rainfall-runoff modeling. The transmission of images is performed in real time by NUMERIS, that is a public telecommunication network for numerical data.

* Computation of images of hourly rainfall amount

Many existing correction methods need to be preferentially applied to polar data (VPR identication correction of attenuation by heavy rain, correction of shielding effects, ...). For that reason, we installed on the radar site

a specific computer receiving from the radar computer CASTOR high resolution polar data for different elevation angles.
For the 3 elevation angles of the Toulouse radar (0.8°, 1.4° and 2,2°), every 5 minutes a polar image is generated by the CASTOR computer and transmitted to a work station for archiving and computations. These basic images contain 820 shots with 254 doors in range; the angular resolution is 0.45° and the radial resolution 1 kilometer. Each pixel is encoded according to a scale of 180 levels of reflectivity.
Hereafter, are shortly described some of the corrections that will be applied to polar images and to raw radar accumulation data in order to transmit images of hourly rainfall amounts to the SHMA.

Ground clutter is identified by computing the frequency of non-zero values of reflectivity for polar data on one month for each of the 3 elevation angles of the Toulouse radar. A pixel with a frequency above 30% is considered as ground clutter.
For the computation of the images in cartesian coordinates, we take into accountthe reflectivity of the polar pixels corresponding to the lowest elevation where groud clutter is not present. That will allow a better detection of rain in mountainous areas.

Estimates of shielding effects are performed from a monthly rain accumulation obtained from polar images compared to an analysis of rain measured by raingauges. A correcting factor can be defined for a given pixel by the comparison of the value of the radar/raingauge ratio with the average value of the radar/raingauge ratio for the pixels located at the same range from the radar.

The influence of the vertical reflectivity profile on radar measurements can be of two different shapes :
- a « bright band » produces an overestimation of rainfall rates when the radar beam intercepts the 0°Celsius isotherm at short range
- when the radar beam reaches cloud tops and when the beam is filled partly with rain and partly with ice, radar measurements are underestimated.
A specific paragraph is devoted, hereafter, to the correction of the VPR.

Diagnoses, performed on a monthly basis, are based on the analysis and intercomparison of radar and raingauge data; a correcting factor is produced and applied to the images of rainfall accumulations. It is a way to take into account some errors that are not explicitely treated.

* Data display and post- processing at SHMA

A first tool for the display of the images of rainfall accumulations on a PC computer was developed at the beginning of the experiment in summer 1996; the software is able to compute the areal rainfall amounts for different sub-basins by integrating the images of rain accumulations,.
A new tool based on a work station, on which functionalities concerning the display of other meteorogical information has been added, is available since the end of 1996.

* Rainfall-runoff modeling
Areal rainfall accumulations are computed for elementary watersheds. The results are issued from a runoff forecasting system based on a multi-model procedure (SOPHIE). This procedure allows the comparison of the results of forecasts from either raingauge data, or radar data.
Several points of runoff measurements are available in the upper Garonne river basin.

3 - First tests on flooding events of autumn 1996

October, November and December 1996 were characterized by heavy rains that resulted in numerous floods on different tributaries of the upper Garonne river basin.
During these rain events, systematic comparisons have were made between rainfall accumulations measured with the raingauge network of SHMA and areal rainfall accumulations deduced from the images of the Toulouse radar.

Division of the upper Garonne river basin into elementary watersheds permits to appreciate the distribution in space and time of rainfall events. A comparison with raingauges located in the elementary areas showed good consistency of the rain values.

Point values given by raingauges represent show the high local variability of rainfall, but are not able to represent the « mean rainfall » on the watersheds. This remark is particularly true for mountainous areas where strong gradients of rain are generated by orographic effects.

Post-processed radar images are integrated for each watershed in order to obtain representative rain heights.

Radar derived areal estimates were used in real-time as an input of the runoff forecasting system, competitively with raingauge data.

The example presented here concerns a tributary of the upstrean part of he Garonne river, named « Salat de Saint-Girons ». The corresponding watershed has an area of 1080 km2; the altitude strongly varies from 380 meters to nearly 2900 meters (Mont-Rouch).

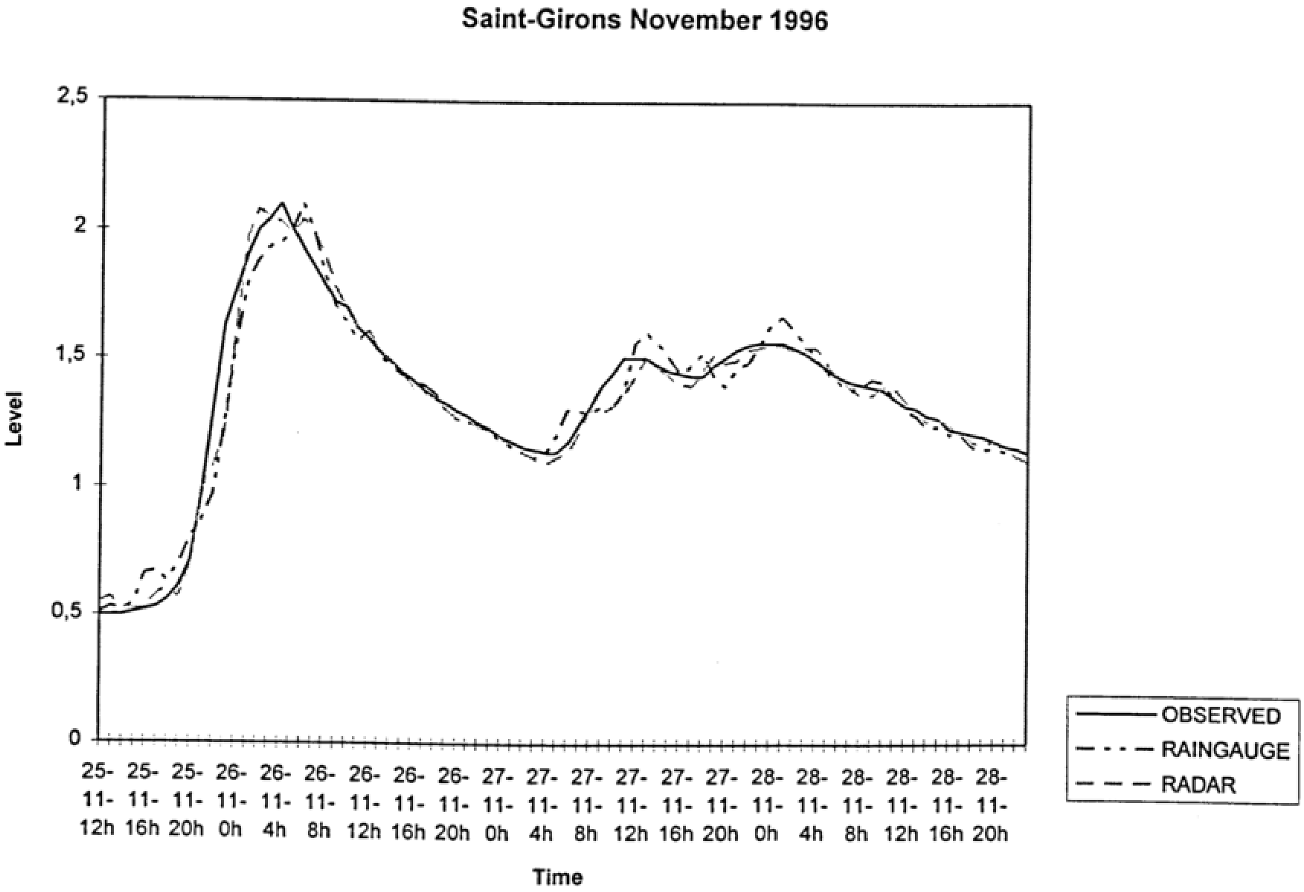


Figure 1

In figure 1, are shown the hydrograms observed at the station of Saint-Girons and 2 hydrograms forecast 2 hours ahead. One of the forecast hydrograms is computed using the data of 3 raingauges located in the watershed;the other is computed using radar derived areal rainfall.

For the 26-November flood, the hydrogram forecast from the radar data is closer to the observed hydrogram, with less irregularities than the one forecast from raingauge data. The fact that radar data are representative of the mean rainfall on the watershed is probably the explanation of these better results; this is particularly true for the more intense stages of flooding, for which the maximum of the hydrogram is better described.

These encouraging results need to be confirmed on other events before a completely operational use of the hydrological method based on the radar data. From now on, with this new tool, flood forecasters of the upper Garonne river basin have a better perception of the situation, and so, of the risk.

4 - Correction of the Vertical Reflectivity Profile

The rain events of autumn 1996 also gave the opportunity to test a method of correction of the Vertical Reflectivity Profile(VRP) effects.
This method is a simplified version of the method proposed by Andrieu and Creutin (1991).
More precisely, the actual ratio curve (ratio between reflectivities observed at different elevations) is compared with calculated curves deduced from pre-selected profiles; these profiles are initialized with values of the heights of the 0°C isotherm issued from a meteorological numerical model and with the heights of echo-tops deduced from radar data. The profile which minimizes the deviation between actual and calculated ratio curves is selected, and the corresponding range correction is then applied.

The comparison of figures 3 and 4 show that, in such an automnal meteorological situation with heights of 0°C isotherm of about a thousand meters, significant underestimations can occur, due to the VRP.

Figures 5 and 6 represent the mean ratio between radar derived accumulations shown in figures 3 and 4 and an analysis of rain accumulations on the same period deduced from the climatological raingauge network (about 200 points on the radar domain).
When a correction of VRP is not performed, a strong underestimation clearly appears for ranges greater than 60 to 70 kilometers; the mean ratio that is close to 0.7 for short and medium ranges move to 3 for a range of 120 kilometers. The rain is thus underestimated by a factor greater than 4.
The correction of VRP significantly reduces those underestimations.

5 - Concluding remarks

To perform flood warnings on small river basins, operational services need to have at their disposal, with a very short delay, estimates, and even forecasts, of rainfall amounts. Raingauge networks have some difficulties to give the right answer, considering the sizes of the areas that need to be observed.
The radar seems to be the instrument able to give the answer to this problem. But, the use of the radar in mountainous areas lead to cope with problems of ground clutter, shielding effects and of vertcal reflectivity profile.
A flood warning service, the French met. office and a research laboratory, in the cooperative frame of GISELE, have built a real-time experimental system for rainfall-runoff modeling from rain measurement by the Toulouse radar.
Strong flooding events that concerned the upper Garonne river basin in the autumn of 1996 gave the opprtunity to first encouraging tests of the complete hydrological application.

REFERENCIES

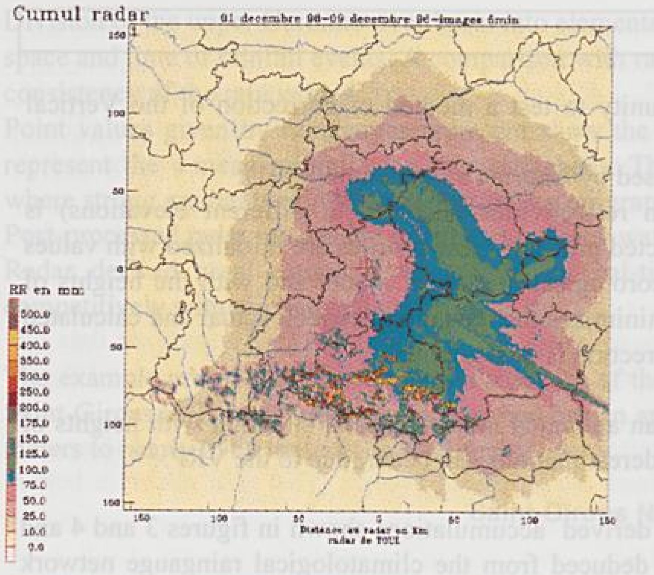
Andrieu, H. and Creutin, J.D. (1991) *Effect of the vertical profile of reflectivity on the rain rate assessment at ground level.* Preprints of the 25th conf. on Radar Meteor. Am. Met. Soc. Paris, 832-835.

Joss, J. and Waldvogel, A. (1989) *Precipitation estimates and vertical reflectivity profile correction.* Preprints of the 24th conf. on Radar Meteor., Am. Met. Soc., Boston, 682-688.

Kitchen, M and Jackson P.M., (1993) *Weather radar performance at long range. Simulated and observed.* J. Appl. Meteor.,32,975-985.

Sauvageot, H. (1992) *Radar Meteorology.* Ed. Artech House, 366 p.

Smith, C.J. (1986) *The reduction of error caused by bright bands in quantitative rainfall measurements made using radar.* J. Atm. Oc. Technol., 3, 129-141.



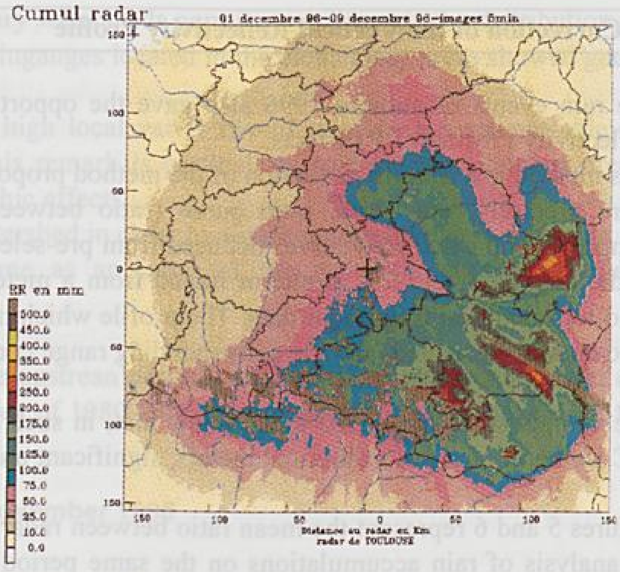


Figure 2 : Rain accumulation from 1/12/96 to 9/12/96 (without VRP correction)

Figure 3 : Rain accumulation from 1/12/96 to 9/12/96 (with VRP correction)

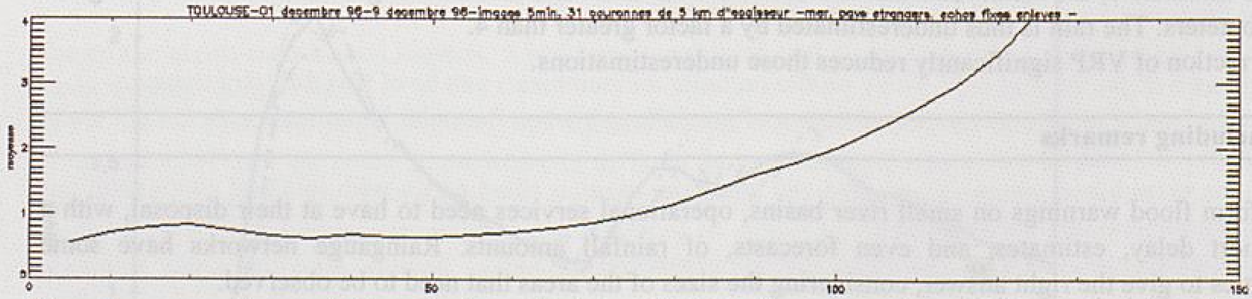


Figure 4 : mean raingauge/radar ratio from 1/12/96 to 9/12/96 without correction of VPR as a function of range (km)

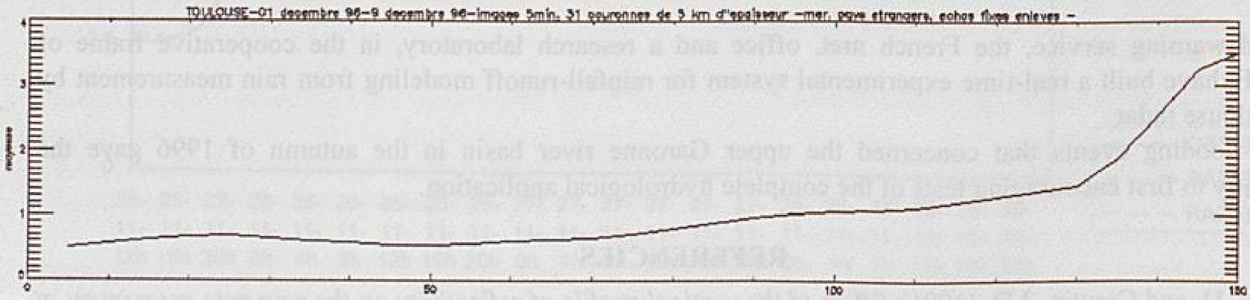


Figure 5 : mean raingauge/radar ratio from 1/12/96 to 9/12/96 without correction of VRP as a function of range (km)

INTEGRATION OF FORECASTING SERVICES IN THE CZECH HYDROMETEOROLOGICAL INSTITUTE (CHMI)

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Preface

At the present the Czech Hydrometeorological Institute consists of three main branches:

- meteorology,
- hydrology,
- air quality control.

This is common in several other central european countries (Poland, Slovakia etc.). This fact allows to produce information not only in the pure form but as true multipurpose forecasts resulting from integration of the above mentioned branches. The data from one branch represent inputs of the other and vice versa.

Another fact is that the Institute is not a strictly centralized organization. The headquarters of all the branches are located in Prague but besides, the Institute has its subsidiaries in each region of the country (i.e. seven regional offices). The subsidiaries are responsible for services at regional level. Each subsidiary has its own management, which is controlled on the administrative basis from the Institute's headquarters in Prague. All professional aspects of the regional branches are supervised by the deputy directors of each branch in the headquarters.

The forecasting services of CHMI

The forecasting services are among the most important duties of the Institute. As mentioned above the Institute including its regional branches does not provide only meteorological forecasts but also hydrological forecasts and forecasts of environmental hazards (such as smog alerts etc.).
The structure of all the forecast services reflects overall the architecture of the Institute. There is one Central Forecasting Office in Prague and regional forecasting centres in the subsidiaries. The main task of this service is to provide accurate forecasting information to the multitude of end users ranging from public media to very special forecasts for road maintenance, agriculture etc. The most important duty of the forecasting services is to operate an effective warning system.

Besides, the outputs of the forecasting centres are not a negligible part of commercial activities of the Institute.

The operational meteorology - warning system basis of CHMI

In order provide a good working warning system both at the headquarters and regional levels there is an essential need of very accurate forecasts. The main providers of the forecast information are the meteorological forecasting centres. These centres provide mainly the following services:

- aviation forecasting and warning service,
- advice and warning on dangerous phenomena,
- special short range or very short range information for different groups of end-users (i.e. road maintenance, power plants, agriculture etc.).

Good working relations exist with other branches including the mutual exchange of information. The following may be noted in this respect:

- hydrological forecasting centre - this centre receives precipitation, temperature and wind forecasts as inputs from meteorology. These information are further processed into hydrological forecasts for dedicated end-users in water management,
- air quality control warning centre - this special warning service uses the meteorological information to estimate diffusion of pollutants in the atmosphere. Especially, warnings on unfavourable dispersion conditions in the lower atmosphere layers, causing smog situations are issued. Recently, these warnings have been very important for specific regions of the country.

In order to achieve good results it is essential that very accurate meteorological inputs are provided. The warning system is provided in compliance with a Czech Republic law. This enables to apply individual warnings on national, regional and private levels. In the field of smog alerts, the warnings represents obligatory inputs for regulation of air pollution sources.

Interconnection with linked services

CHMI had to take necessary steps to be able to provided all the above mentioned services. The meteorological forecasting centre was established as the primary information source, the other forecast services i. e. hydrological and air quality control have the secondary status.
This architecture increases the demands on operational processing of primary meteorological information and their on-line multilevel applications. This system is highly sophisticated and provides outputs on central and regional levels.
This is possible only with good hardware equipment and software support of the forecasting centres. Also a good working data network is essential.
Further development of the remote automatic weather stations network, which is aimed mainly to indicate precipitation, is also very important. The outputs will be used mainly in modelling - especially for hydrological forecasts.

The Automatic Imission Monitoring System network of CHMI is on very good standard. This system is monitoring air quality in real-time (SO_2, NO_x, CO, O_3, fly dust) and also includes measurements of several meteorological values. This system provides essential support to the smog warning system and also helps to increase the density of meteorological measurements from professional observatories of CHMI and the remote automatic weather stations network.
The application of national weather radar network, meteorological satellites images and numerical models are currently basic tools of forecasters.

Outlook

In the near future CHMI will further develop the forecasting services into more complex an sophisticated system of warning service.
The system will include establishment an integrated forecasting centre with 24h service and branches for synoptic meteorology, aviation forecasting and warning service, regional forecasts and special applications.
The main task is to proceed in the development of regional services. To name one of the most progressive field of applied meteorology is the road weather information service. This is a very complex system built in close collaboration with the road administration focusing on the phenomena which affect the road surface conditions. CHMI provides forecasts and effective distribution of the information.
The Institute has to concentrate on the commercial meteorological applications. There is a wide variety of products for many potential end-users. The central forecasting centre will further employ also hydrological and air quality control in the full scale.
The regional centres on subsidiaries will be organized on similar basis. The continuous service will be able to provide the basic information for experts from the field of hydrology and air quality control. They will have the necessary tools and skills to provide a valid information up-to certain level. This level will be valid for defined warning in all fields.

Conclusion

This article describes the efforts in building an integrated forecasting centre in the CHMI. The centre follows the branch structure of the Institute and the links in data and information flow. It enhances the mutual collaboration of the services. This is possible only when the branches are managed from one centre.
The main advantage is the mutual information exchange, sharing of communications and computing equipment and manpower. This leads to high efficiency of the service and substantial decreasing of costs.

COMMERCIAL ACTIVITY AT THE HUNGARIAN METEOROLOGICAL SERVICE

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The Commercial Division of HMS was established on January 1, 1993 to carry out work connected with the basic activity of the Service not supported by the State budget. The Commercial Division (CD) gives its services partly based on the synoptic activities of the Weather Forecast Department in a form and content that meets the requirement of our customers. On the other hand in the field of climatological services CD co-operates with the Climatological and Agrometeorological Department.
The basic of our activity is the good and special connection between the HMS and CD. This types of the connections are professional and financial ones.

Special weather forecasts are made in the forecasting group of CD on the field of

Media	Agriculture
Energy	Industry
Transport	Water management
Premium telephon	Construction
	Others

More than 90 % of our income comes from the first four sectors . All the other sectors provide only about 5 % of the revenue.
In the last four years and also in 1997 our primary activity has been to provide weather information to public (TV, radio, newspapers and premium rate telephone).

Our services on the territory of media are:

- *Television, teletext*
- *Radio*
- *Newspapers*
- *Premium rate telephon,*

and they contributing the largest share of the revenue.

Television, teletext

There are two public TV channels (MTV and DUNA TV) and many commercial TV broadcasts in Hungary. The presenters of the weather forecasts in the public TV are only meteorologists, who are all the employees of the CD. The quality of the TV presentations must improve and must implement the new techniques.
There are weather news on the end of the most important news-programs 4 times almost every day.
We provide short and medium-range forecasts in the TV broadcasts and special information: air quality, UV B information, pollencount, biometeorological news, since they hit such a large audience and can be emphesasised by the presenter. Our connection

with the commercial TV network is not close and we must face a quite new situation because of the new media -law.
Teletext is a good medium for broadcasting more detailed weather information.We have in the public TV 10-15 weather pages. Market searches show that a large percentage of the public use the teletext, so we are ready to give services in new system.

Radio

There is a wide range of public and local commercial radio stations in Hungary. Our contact with the public radio and the leader commercial radio stations is very good. The weather forecasts are said by meteorologists on the end of the main news programs in the public radio. There has been a special line between the CD (HMS) and the public radio since 1969.
Otherwise the radio weather services seem best suited to specific local information such as the stormwarning on the lake Balaton.

Newspapers

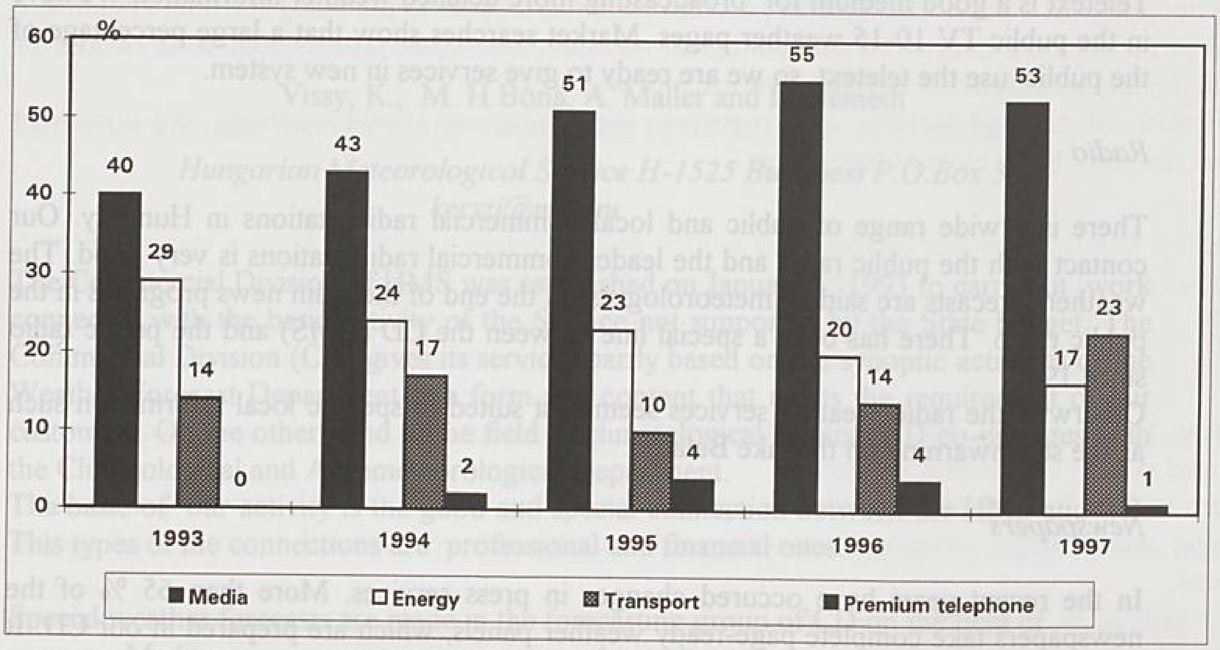
In the recent years have occured changes in press services. More than 65 % of the newspapers take complete page-ready weather panels, which are prepared in our CD. It caused for the CD considerable benefit. The other part of the newspapers are made on conventional way, but changes are expectable.

Premium Rate Telephone

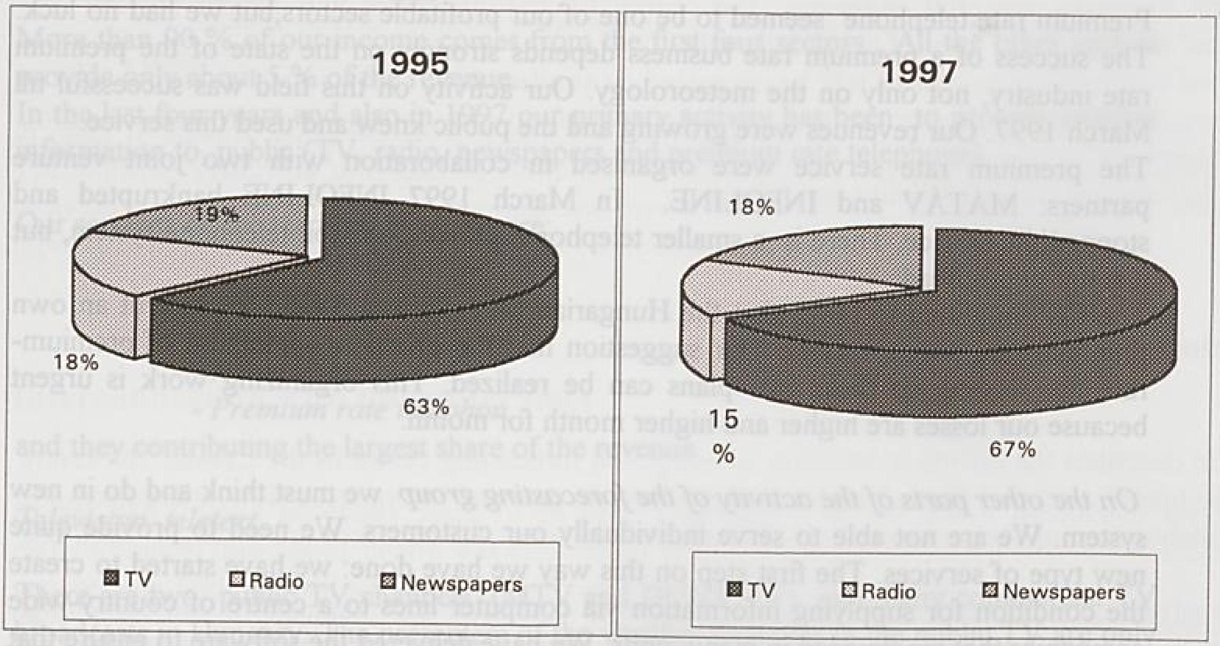
Premium rate telephone seemed to be one of our profitable sectors,but we had no luck. The success of a premium rate business depends strongly on the state of the premium rate industry, not only on the meteorology. Our activity on this field was successful till March 1997. Our revenues were growing and the public knew and used this service.
The premium rate service were organised in collaboration with two joint venture partners: MATÁV and INFOLINE. In March 1997 INFOLINE bankrupted and stopped the service. There is a smaller telephone service on mobil telephone system, but it is not widespread.
The CD suggested to HMS that the Hungarian Met. Service should implement an own premium-rate phone service. Our suggestion met the president's intention of premium-rate fax service, so these two plans can be realized. This organizing work is urgent because our losses are higher and higher month for month.

On the other parts of the activity of the forecasting group we must think and do in new system. We are not able to serve individually our customers. We need to provide quite new type of services. The first step on this way we have done: we have started to create the condition for supplying information via computer lines to a centre of country-wide companies that are devided in many units. We have delivered the software to ensure that the individual units have access only to information they ordered. The main advantages of this new system are the considerable savings in the field of telecommunication costs and the rationalised organisation of our work.
This new contact has effected the best way between the Hungarian Oil stock company (MOL) and CD.

Growth in Commercial Revenue of four Branches
(1993-1997)



Distribution of the Revenue of Media-Sectors
(TV, Radio, Newspapers)



References

Maller A, K.Vissy, 1994: Commercial activities in weather forecasts at the Hungarian Meteorological Service *Met. Apps. I. 85-88*

Vissy K., A.Maller, 1995: Application of weather forecasts to different categories of end-users on a commercial basis in Hungary *ECAM-95*

RiPP; a Development Project for Increased Efficiency and Automatization of the Production Process in Sweden

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1. Introduction

The Swedish Meteorological and Hydrological Institute (SMHI) has for some years now been modernising and improving its observing system (OBS 2000), Mesoscale analysis (Mesan), HIRLAM modelling system, processing and communication, forecast tools and procedures, and dissemination system. This work will culminate in 1998 with the deployment of RiPP (Rationalization in the Production Process).

One of the problems of an operating forecast service today is that the forecasting procedure is rather labour-intensive. On one hand, advances in new observing systems, especially remote sensing systems, new model outputs and rapid communication technology has put an enormous amount of data to the forecasters disposal. On the other hand, end-users also need more sophisticated weather information, and the weather service has faced increasingly complex demands for more specialised and tailored forecast products. Great efforts have already been done in increasing the productivity by automatic collection and distribution of information. An increased efficiency in the weather service must now come from a higher degree of automatization in the forecast production.

Improved Numerical Weather Prediction (NWP) due to refined numerical models and statistical interpretations have led the weather service to examine how human forecasters really can add value to the forecast process. An important part of national weather services is also to account for the public health and safety in hazardous weather situations. Much of the human added value in the forecast process is a consequence of human pattern recognition skills, and human judgement and decision making skills in the face of uncertainty.

The RiPP-system has been designed with these issues in mind.

2. The RiPP-system

The future weather service system at SMHI is schematically illustrated in Figure 1. The main components of the system are; the data base, the automatic assembly module incl. graphics and text generators, the production control, and the dissemination system.

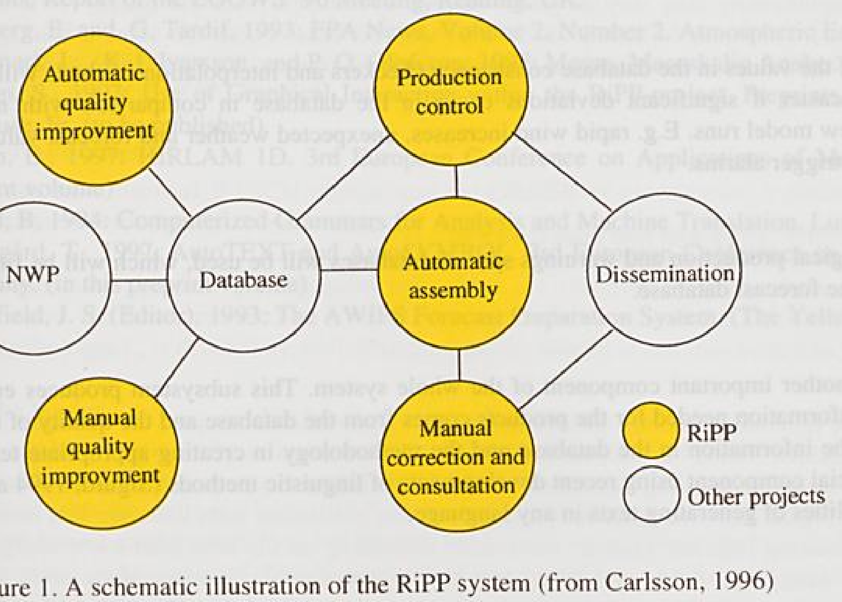

Figure 1. A schematic illustration of the RiPP system (from Carlsson, 1996)

The RiPP-system has as far as possible been developed in an object-oriented way. The different modules will either be new components or appropriately encapsulated older modules. They will be separated by well defined interfaces. Another mission in the project has been to use standardised components and standard libraries.

The data base

One of the main components in the forecasting system is the database. This module includes the real-time database of RiPP, the forecast database and other special databases. The database will be built on a commercial relational DBMS, and at the end of 1996 Informix Universal Server was chosen. One important aspect of this choice was the future possibilities to handle objects within the database.

The real-time database

The real-time database of RiPP includes all basic information; observations, analyses as Mesan (Häggmark et al, 1997) and different numerical forecast guidance in grid form as Mesan + 1D HIRLAM for nowcasting and VSRF (Olsson, 1997), HIRLAM for short range and ECMWF incl. ensemble forecasts for medium range forecasting. In order to improve the quality of certain forecast parameters statistical aids (e.g. MOS or Kalman filters) will also be used. The intention is that there will be very little human influence on this database. We will, however monitor the HIRLAM model, and for the automatic production the forecaster sometimes will have to choose a different model through a steering procedure.

Forecast database

In the forecast database special key parameters or sensible weather parameters will be monitored manually. Values in this database will be updated with information derived directly from the real-time database. The forecaster will modify and maintain the forecast database in order to create a certain quality (measured through an on-going verification scheme) of the future state in the defined forecast area.

Advanced interactive graphical tools are needed in this position in order to create modifications of data or graphics. Different kinds of tools are needed in the weather service; tools operating directly on field information in grid formats (as in the American AFPS (AWIPS (Advanced Weather Interactive Processing System) Forecast Preparation System), see e.g. Wakefield et. al, 1993) or represented as cubic B-splines (as in the Canadian FPA (Forecast Production Assistant) system, see e.g. Goldberg and Tardif, 1993), and a tool kit operating on different kinds of objects like fronts, precipitation areas etc. (which might be generated automatically from NWP or from a forecast database). FPA has been evaluated at SMHI during 1995 and AFPS during 1996.

Recently a new method has been developed at SMHI, which is based on some of the ideas behind Mesan, where asymmetric structure functions are used. Three different techniques have been implemented in a prototype system. 1) A point value can be set or 2) an increment can be added or subtracted from a forecast field. The influence on the surrounding area declines as a function of horizontal distance. The distance function is optionally modified depending on the difference in topography, fraction of water and possibly vertical velocity caused by orography and wind, providing the ability to create and maintain sharp gradients in coastal and mountainous areas. 3) Finally, a change of all values to a constant value within a marked area (defined by a polygon train marked on the chart) can be made (e.g. elimination of precipitation that might be incorrect). (See also Nilsson, 1997, for more details.)

In order to keep an internal consistency of the values in the database consistency checkers and interpolation methods will be used. Alarm systems will alert the forecaster if significant deviations occur in the database in comparison with new observational data as well as data from new model runs. E.g. rapid wind increases, unexpected weather and forecast values, which differ to much from reality, should trigger alarms.

Other databases

For aviation services, marine and hydrological production and warnings special databases will be used, which will be filled with data from the real-time database or the forecast database.

Automatic Assembly Module

The automatic assembly of products is another important component of the whole system. This subsystem produces end-users products (texts and graphics). The information needed for the products comes from the database and the quality of the products depends on both the quality of the information in the database and the methodology in creating appropriate texts and graphics. Texts are generated in a special component using recent developments of linguistic methods (Sigurd, 1994 and Vävargård, 1997), which gives the possibilities of generating texts in any language.

The primary consideration governing the development of the automatic assembly module has been flexibility. Products are described by textual descriptions and by changing the descriptions you may change the product. Thus, a variety of forecast products can be generated automatically from the database.

A first version of the automatic assembly module has been developed in order to verify the proposed production model (a distributed model using client/server concepts), to demonstrate how a modern forecast production system operates (using the just-in-time concept), and to evaluate new techniques as e.g. Corba for communication between components within a distributed system. The results from the first stage will be used in the iterative process to finalize the automatic assembly and the methodology for generating text and graphics.

Production control
This subsystem is responsible for the control of the automatic assembly. The subsystem will also contain components that supervise the database and trigger alarms at certain events or if previous forecasts differ too much from reality.

Manual correction and consultation
This subsystem is used by forecasters to view and, if needed, correct automatically generated products. It will also be used by forecasters working in direct contact with customers needing special attention. The subsystem will as much as possible be built on standard PC components such as text editors, graphical editing tools, web browsers (for internal use).

Dissemination
The dissemination system is also of great importance. When we have produced sufficiently accurate, site or area specific forecasts, we must be able to deliver this information to customers who need it to make correct and timely decisions. This is especially important for the emergency services. Therefore, the development of customer-tailored dissemination techniques and formats will have a high priority at the end of the RiPP-project.

3. Summary

The Swedish Meteorological and Hydrological Institute is like many other national meteorological services in a phase where the whole production chain is renewed from the observing system to the interface with the end-user. This is accomplished by a combination of in-house developments and implementation of selected imported components.

Key words in this modernization is
- automatic procedures
- sustainable architecture for systems, modules and components.

References

Carlsson, H., 1996: Automatic Production and Distributed Systems in the RiPP Project.
Preprints, Report of the EGOWS '96 Meeting, Reading, UK.
Goldberg, E. and G. Tardif, 1993: FPA News, Volume 2, Number 2. Atmospheric Environment Service.
Häggmark, L., K. I. Ivarsson, and P. O. Olofsson: 1997: Mesan, Mesoskalig Analys. SMHI RMK Nr 75 (in Swedish).
Nilsson, S., 1997: Use of Graphical Interaction within the RiPP-project. Preprints, Report of the EGOWS '97 Meeting, Toulouse, Fr. (to be published).
Olsson, E., 1997: HIRLAM 1D. 3rd European Conference on Applications of Meteorology, Lindau, Germany. (in this preprint volume)
Sigurd, B, 1994: Computerized Grammars for Analysis and Machine Translation. Lund University Press, Lund.
Vävargård, T., 1997: AutoTEXT and AutoSYMBOL. 3rd European Conference on Applications of Meteorology, Lindau, Germany. (in this preprint volume)
Wakefield, J. S. (Editor), 1993: The AWIPS Forecast Preparation System. (The Yellow book).

RiPP; Autotext and symbol

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1. Background and identification of the problem

Meteorology consists in fact of two main parts. First we have to forecast the weather, then we face the problem of transmitting the substantial information to the end user. In this paper we concentrate on the problem of how to use a meteorological numerical database to produce information understandable and tailored to meet the end user´s requirements. The meteorological models are becoming more and more accurate and detailed. The information techniques have to match the development and become more flexible to increase their capability to describe the results from the NWP. It is a fact that the forecaster´s job is turning into a journalistic task. We find that a forecaster is spending more than half of the time to formulate and edit forecast information in textual form.

There is a trend going on to rationalise the job by substituting the fluent text information with tables and graphs and save some time, but the tables and graphs do not cover the requirements of all customers. Users having a rather basic knowledge of meteorology e.g. sea captains, environmental engineers or pilots will all benefit by having a text that describes the overall weather picture that can give hints about an alternative forecast development instead of just a straight forward figures and facts sort of information. There is much to gain even when producing more fundamental meteorological products by matching them with needs of the user and with the prevailing weather situation. There is a risk to get a random amount of information by going straight from a database to a table. A day with no clouds and + 10 degrees the forecast table says 0% risk of snow. A table is always filled with information whether the information is relevant or not. We have far too much random flow of information hitting us every day and people are getting fed up with it. Something even worse may be to deliver some information with contradicting facts.

At SMHI we have a tradition since 1960's to transform meteorological NWP information automatically to textual forecasts. Until recently we have tried to solve both meteorological and linguistic problems in one program using traditional programming techniques. There are limitations. It is hard to reuse the programming efforts as they are all tailored to do a special type of forecast text and the programs tend to go very complex rather soon. The complexity is caused by the mixture of rules taking care of both meteorological and linguistic problems. The result (canned text) is a limited set of prefabricated sentences or parts of sentences and then we squeese the forecast information in to these. We are now at SMHI adopting the "natural language method". The rest of this paper will be a description of the natural language way of doing meteorological forecast texts.

I have now and then for a period of ten years worked with text generators in the field of meteorology and as I see that automatically produced texts have a significantly long way to go to be able to compete with the quality of a human forecaster, giving a fluent description of a forecast in collaboration with the end user. There are some advantages in automatic texts. The text becomes more strict and uniform and it is easier to verify the forecast. The text can be produced in many languages at the same time.

2. The approach to a solution

The problem of producing text automatically can be split into three questions.

WHAT to say?
In what ORDER to say it?
HOW to say it?

The first two questions is the part of the process we usually call the text planning phase. It is this part that contains all the intelligence of the process. The last question "HOW" is answered with a set of rules containing the logic of the language and a lexicon. Details of this you'll find under the heading " generating text". The work in this project is focused on knitting together linguistic science with meteorological knowledge. In the daily production of forecast texts there are lots involved; analysing the weather situation and extracting relevant weather information depending on the forecaster´s knowledge and consideration of the customer and the customer´s needs etc. When you try to automatically produce these texts you´re tempted to make gross simplifications and generalisations that don´t reflect the real quality of today´s meteorological data bases.

Let me give an example! Today we present the temperature of a point or a small area as a simple mean value. This is done automatically day out and day in, summer and winter. Instead we could describe temperature as max and min in the area or temperature with a trend: "rapidly rising", "slowly falling". And temperature could be linked to the cloud situation. "tonight clearing and temperature fast dropping below zero". To be able to produce this kind of information automatically we´ve found it nessesary to use a text planner that gives the answer to our two first questions. WHAT to say and in which ORDER.

3. The text planner

3.1 Objectification

After studying meteorological texts from different countries we found that they all consist of information carrying objects. Examples of objects on the synoptic scale are High, Front, Cold air mass; On the mesoscale, sea breeze; On local scale, wind, temperature, clouds. Some of the objects can be used to to carry information from all three scales. Objects are identified by their characteristics. E.g. wind has the characteristics speed, direction, degree of gustiness and the characteristic that it can be connected to other objects. When the objects are found, we define rules that can be programmed to extract them automatically from a data base.

3.2 The selector

All information carrying objects are not relevant to be included in all forecasts. We must find a structure of rules to be able to choose the objects needed to represent the adequate information. By studying texts written by forecasters and connect them to the weather situation and customer group we can get some rules telling us which information carrying objects the customer wants. To define the type of weather situation an automatic pattern recognision must be carried out. We have not done this yet. There is a way around this by letting the forecaster classify the weather situation, say, every twelve hours.

A set of rules will control the relevance of the selected objects and the connection between them. If some object is found to be unneccesary it will be dropped. The main selection method of finding what should be said, i.e. which information carrying objects to include, is through a customer profile. The structure of these profiles is WHICH object to include and in what ORDER. We estimate the need for about five customer profile structures, marine forecasts, general forecasts, radio forecasts, newspaper forecasts and aviation forecasts. These structures have tuning parameters enabling us to set the information content and to decide the order of the objects and how they should be connected.

The value of the tuning parameters are partly decided by the specific demand of the customer. A yacht club, belongs to the structure "marine forecast" but are specifically interested in wind shifts in the afternoon and evening but not night/morning. Otherwise they follow the structure "marine forecast".But the yacht club is satisfied with the standard marine forecast if wind speed exceeds 20 m/s the whole forecast period. This condition can be filled by analysing the forecast data base before we decide how to represent the information object WIND. We can also insert rules about coordination between the different objects. By this kind of method we should be able to get texts like :" The northerly wind brings snow showers." We are yet to implement such coordination rules. Much work remains when it comes to customer profiles and we are still to test the full potential of this method.

3.3 Variant selector

When we have decided WHICH objects and the ORDER of presentation it remains to set the objects so they carry the information in best possible way.

We have found that in meteorological texts there are different variants of the same information carrying object e.g. temperature can be represented as a mean or as max/min or as "raising to" value or an "about" value. The best way to express the object , is decided by analysing the forecast data base and matching it to the customer demands.

3.4 The loader

When we have come so far as to have selected the objects with the right variant and placed them in the correct order it is time to fill the information structure with facts. Up to now in this process we have used the meteorological data base in co-operation with the customer profile only to find out WHICH type of fact and in which ORDER to represent these facts. Now we know exactly which facts we are looking for and we can enter the forecast data base to extract and post process so we get exactly what we want. This is a controlled way of processing a forecast data base. It is much more difficult to go into the data base and without considering either the present weather situation or customer demands, extract all kinds of meteorological information for all kinds of time and geographical scales, store this information and first then analyse the information.

4. Preparators

4.1 The text preparator

To bridge the gap between the mathematical scientific, logical environment to the human linguistic world, you need an interface transformer that we in this project has named "text preparator". In the preparator information from the data base is supplemented by special meteorological phrases that are dependent on the true values of the objects extracted from the forecast data base. Examples of such expressions are that the wind is "VEERING" and the temperature is "FALLING" etc.

4.2 The symbol preparator

Each object can be represented by a symbol. Combinations of objects that can be expressed textually can sometimes be expressed by combinations of symbols but more often they have to be fragmented into single objects with a unique representation. We have not so far worked much in this field. We have noticed that our customers often want their own set of symbols. We will from the system deliver a complete representation including all objects in the forecast with all their properties. It is up to a Symbol Generator to map this information into a limited number of pre-choice symbols.

5. Generating text

The text generation module produces text on the basis of the representation of the meteorological facts it receives as input. The text production takes place in several steps. First, the code words in the representation are translated into language independent semantic representations, consisting of the meaning of the word and some linguistic information like plural, tense etc. The choice between possible synonyms are governed by the customer profile. The second stage involves extracting information from the input and grouping the information into fact clusters, suitable to express with a single sentence. These clusters are called text facts. They constitute the basic building block of a sentence or the minimal amount of information needed to form a proper sentence without leaving out pieces of information that cannot be placed in an other sentence.

The next step consists of expansion of text facts into sentence facts, which are more close to natural language. During this process, articles (the, a/an), verbs, conjunctions (and) and to some extent also prepositions are inserted where necessary. More than one text fact can be utilized to form one sentence fact, e.g. when the resulting sentence is coordinated (e.g. two clauses joined by (and). The sentence facts consists of a functional grammatical representation (i.e. the sentence divided into subject, predicate, object and adverbials) and a rhetorical type parameter (e.g. full sentence or telegraphic sentence).

The last step is the textualization process, where the functional grammatical representations are translated into text. This is accomplished by language dependent grammar modules, morphology modules and lexicons. For the time being, text can be generated in either Swedish or English. The grammar formalism used is called Swetra grammar (Sigurd, 1994). The grammar module is responsible for checking that the output will be grammatical sentences and it calls the morpholgy module when word inflection is necessary. The lexicons contain uninflected forms and use the same word semantic representations as mentioned above.

References

Sigurd, Bengt. Computerized Grammars for Analysis and Machine Translation. Lund University Press, 1994.

Bengt Sigurd, Birgitta Lastow and Tomas Vavargard: A paper given at the 12th European Conference on Artificial Intelligence 1996, Computer Generation of Weather Overviews,.

Lindh and Nilsson,1997: RIPP a Development Project for Increased Efficiency and Automatization of the Production Process.(in this preprint volyme)

COMMERCIAL WEATHER SERVICES ON THE INTERNET

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ABSTRACT

It is about 3 years since the Internet and the World Wide Web first came to the public attention. Since then the number of Internet websites and users has grown at an astonishing rate. National Met Services and private weather companies have set up websites, and are also supplying information to other web publishers (as they had done before the Internet with online systems such as Minitel and Compuserve). The WMO website (**http://www.wmo.ch/**) and the Virtual Library of Meteorology (**http://www.ugems.psu.edu/~owens\WWW_Virtual_Library/**) provide a comprehensive list of weather resources on the Internet - about 40 National Met Services presently have websites.

The Met.Office set up a free public website (**http://www.met-office.gov.uk/**) in October 1995, and this now delivers on average 10,000 to 15,000 pages of information per day, rising to 25,000 pages in severe weather. The site is fairly typical of a National Met Service, providing a range of free public service information, background and educational information, details of premium rate services and details of specialist commercial services with a response facility for further information. The site was designed with the following objectives in mind:

- to deliver the Public Meteorological Service
- to improve the public image of The Met.Office
- to generate premium rate revenue
- to generate commercial leads
- to research the possibility of a commercial website

After 6 months an on-line questionnaire was placed on the site and attracted over 650 replies in 11 days. The survey provided a profile of the users and their interests, and highlighted requirements for additional information. Most users said the site had had a positive effect on their opinion of The Met.Office. 24% of users visited other European weather sites, 19% US sites, and 14% other sites worldwide. Opinions towards paying for information were more favourable than expected, and this together with other results justified the development of the MetWEB commercial site.

By using dedicated premium rate numbers on the website it has been possible to estimate the revenue generated through this advertising medium. Direct commercial leads have been disappointing and reflect the current trend for users to be visiting the

site for personal or leisure use, rather than business or education. Nevertheless, the commercial revenue from the site is significant and has justified a presence on the Web.

Commercial transactions on the Internet are, in general, mainly confined to consumer items such as books and CDs, computers and accessories - usually purchased with credit card. Charging for information is less advanced, partly due to the early culture of the Internet. The absence of a global micropayment scheme for simple low value transactions (similar to premium rate on the telephone for example) has held up progress, or forced publishers to rely on advertising revenue instead. There are various competing micropayment or digital cash schemes being proposed (see **http://www.sims.berkeley.edu/resources/infoecon/Commerce.html/** for a review and listing of commerce web activities), but still these seem some way off. The advent of such a system, or indeed a pan-European premium rate, offers the possibility to mass market low value services to a wide audience, but would pose problems for ECOMET which insists that we record the territory of all customers, together with the details of their purchases - this may not be possible (or desirable for administrative reasons) under such systems.

On the MetWEB site (**http://www.met-office.gov.uk/MWIntro/MWIntro.html/**) we have designed a simple system which uses prepaid books of electronic tickets. Users register their personal and credit card details with us, via a telephone helpline. Our research shows that customers are still wary of online credit card security. Thereafter they can top up their tickets on the website without using their credit card, and do not need to contact us. The MetWEB site contains a wide range of General, Marine and Aviation forecasts, together with charts, satellite images and observations. Entry to the site is paid for with a ticket, and thereafter access to many products requires further tickets to be spent. The site is aimed at leisure users (sailors, pilots, walkers etc) and is actively promoted in these areas. A small number of business and overseas users have joined the service. Financially the site is performing ahead of plan, and further development is planned for next year. It is interesting to note that many of these customers are users of services such as Compuserve or AOL which offer free weather to subscribers!

The New Zealand MetService operate a commercial web service, WeatherNOW! (**http://www.met.co.nz**) in conjunction with a local Internet Provider who take care of all the customer billing. Access to this site is restricted to customers of the Provider and this limits the user base, but there is a healthy interest in the service. The Australian Bureau of Meteorology (**http://www.bom.gov.au/**) is presently trialling Restricted User Services on the web.

In US, it is possible to subscribe to free Internet email weather services (for example WeatherVane at **http://www.merc.com/** from Weather Channel), by registering details on a website. The Weather Channel is also also delivering a graphic product on a similar basis using BackWeb Internet "push" technology. At the Accuweather site (**http://www.accuweather.com/**) users can register for their free (at present) Personal Accuweather Service. The size of the Internet industry in US, and its ability to command large advertising revenues, inevitably leads to a wider selection of free weather supported by advertising (e.g. Weather Channel at **http://www.weather.com/** and Washington News at **http://www.weatherpost.com/**).

Even in the UK there is plenty of free weather content on the web, some published by our very own media customers (e.g. **http://www.telegraph.co.uk**). The challenge for Weather Providers is to satisfy publishers wishing to buy information for publication on their free sites to increase traffic and advertising, and also to use the same technology to deliver premium products directly to targetted audiences. In both cases there are risks in eroding existing business (say on premium rate telephone and fax services). In the UK at least, it seems possible to operate all business models while the Internet has a low level of penetration (about 10% of the public have access to the Web). In specialist areas such as sailing and flying we have found a much higher use of the Internet, so here more care must be taken in managing these distribution channels.

The global nature of the Internet offers commercial potential to weather publishers, equally the vast range of free information available poses a threat. Both issues seem lessened in practice by language differences and the need for translation software. Needless to say, such translation software is now available to plug in to a web browser, and will become less of a problem in future! Another issue for publishers on the web is that of copyright and and controlled use of information. Basic weather forecasts have such a short useful lifespan that this is probably not a big issue, but delivering climatological data this way could be risky.

A wide range of parallel developments, such as Web-TV, and hand-held PCs with mobile phone access to the Internet, look likely to make the Internet an important and wider medium for information delivery in the future. The experience of The Met.Office is that real commercial benefits can already be gained from the Internet today, and valuable experience in this fast moving environment is being gathered for the future.

Wind and temperature nowcasting for air traffic management

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Introduction

Forecasting of winds and temperatures on timescales as short as 20 minutes ahead is expected to feature as an important requirement in the enhanced air traffic management systems currently under development for implementation within Europe early in the 21st century.

The UK Met. Office under funding by PHARE (the Programme for the Harmonisation of Air traffic management Research in Eurocontrol) has developed WAFTAGE (Winds Analysed and Forecast for Tactical Aircraft Guidance over Europe), a wind and temperature nowcasting model, which can produce timely and accurate forecasts for aviation.

Trials were carried out with WAFTAGE as part of the PHARE Met. Task. WAFTAGE demonstrated that it could produce a forecast, updated hourly, that could halve conventional Numerical Weather Prediction (NWP) temperature forecast errors and reduce wind errors by a third.

As part of the EC DGVII ARAMIS (Advanced Runway Arrivals Management to Improve airport Safety and efficiency) project, to reduce congestion in the airport terminal area, WAFTAGE demonstrated that it could produce forecasts, updated every 15 minutes, that reduced NWP wind forecast errors by a quarter. NWP errors are normally lower near the surface anyway, but it is hoped that even this 25% improvement could have a significant impact on the trajectory prediction part of the ARAMIS model.

WAFTAGE

Although NWP forecast fields hold a lot of invaluable information on the dynamic state of the atmosphere they have two drawbacks when it comes to providing accurate forecasts for air traffic management:

i) There is always a time lag of several hours between wind and temperature observations being made and an NWP forecast based on those observations being available for use.
ii) Computing power limits the amount of observations included in an NWP forecast so that for small areas, like airport terminal areas, fine detail is lost.

WAFTAGE is designed to avoid these drawbacks by assimilating recent, site-specific observations into NWP forecasts.

WAFTAGE is a software package that can run on an HP or VAX. To forecast for a given area and time it requires as inputs a data file containing a relevent NWP forecast and a data file containing recent (within the last hour), site-specific (within 100km) observations. WAFTAGE combines the NWP forecast with the observations, using a process called optimal interpolation, to produce an improved forecast in the same data file format as the original NWP forecast.

PHARE

To test WAFTAGE trials were carried out using British Airways flight recorder data from all BA flights on 9th February 1994 between 47.5°N and 55°N, and 7.5°W and 7.5°E. The flight recorder data were grouped into twenty-one, over-lapping, 3-hour data files (i.e. 00-03Z, 01Z-04Z, 02Z-05Z, ... 20-23Z - the 'analysis' periods). These were used as input to WAFTAGE along with twenty-one 1-hour NWP forecast data files for the following hours (i.e. 03-04Z, 04-05Z, 05-06Z ,.... 23-24Z - the 'forecast' periods). The NWP forecasts were produced from the 00Z run of the Met. Office's Local Area Model (LAM). From these input files WAFTAGE produced twenty-one corresponding WAFTAGE nowcasts for the forecast periods.

The accuracy of these WAFTAGE forecasts was verified by comparing them with the BA flight recorder values of wind and temperature measured in the forecast periods.

Figures 1 and 2 show the accuracy of both forecasts throughout the day for RMS temperature error and RMS wind vector error respectively. There are three conclusions to be drawn from these graphs:

i) WAFTAGE results were better when more observations were input. Before 08Z in the test region observation densities tended to be low simply because there were fewer flights at this time and WAFTAGE forecasts, although not worse than NWP forecasts, were no better either.
ii) WAFTAGE temperature forecasts were more accurate than conventional NWP temperature forecasts. Temperature forecast RMS errors were around 1°C for WAFTAGE compared to around 2°C for NWP forecasts.
iii) WAFTAGE wind forecasts were more accurate than conventional NWP wind forecasts. WAFTAGE RMS wind vector errors, given sufficient observations, were around 4m/s based on an NWP forecast that was six hours old, rising to 6m/s for an NWP forecast that was 18 hours old. Corresponding NWP RMS wind vector errors were 6m/s rising to 8m/s.

ARAMIS

Similar tests using BA flight recorder data from 24h January 1995 were done for the ARAMIS project. Only observational data from flights in the London Heathrow airport vicinity (50.875°N-52.125°N, 1.4°W-0.6°E) were used. The observations were grouped into forty-four input files each for one of forty-four overlapping 1-hour analysis periods between 06Z and 17Z (0600Z-0700Z, 0615Z-0715Z....1700Z-1800Z). The Met. Office's 06Z run of the LAM was used to provide forecast fields files for the 15 minute period immediately following each of the analysis periods. These were combined with the observations using WAFTAGE to produce corresponding WAFTAGE forecast fields files.

The forecast fields files from both the LAM and WAFTAGE were used to forecast wind speeds and directions at points along the flight paths of individual flights approaching Heathrow. These forecasts were compared with observations made by the flights to verify the forecasts' accuracies.

Figure 3 shows the results for one aircraft as an example of what WAFTAGE can achieve. The top half of the figure shows the flight path of the aircraft as it entered the Heathrow terminal area and the locations of observations made in the previous hour by other BA flights. The bottom half shows the error in the forecast of headwind strength experienced by the aircraft as a function of its flight level (10FL represents approximately 1000 feet).

The NWP forecast for the aircraft tended to underestimate the wind speed by up to 5m/s between FL150, where it entered the terminal area, and FL30 where it turned to fly east. Below FL30 the NWP forecast overestimated by a similar amount. For air traffic management it is the combined error along the total flight path that is important and for this particular flight the NWP forecast errors averaged out at an underestimate of 3.25m/s.

In contrast, the WAFTAGE forecast not only produced a better forecast at individual points along the flight path but tended to overestimate and underestimate by equal amounts producing a combined error along the approach of an overestimate of headwind speed of just 0.75m/s.

Figure 4 shows average results for all 79 flights. WAFTAGE wind forecasts were more accurate than conventional NWP wind forecasts. WAFTAGE RMS wind vector errors were around 3m/s. Corresponding NWP RMS wind vector errors were around 4m/s.

Conclusions

Trials have shown that the Met. Office's WAFTAGE model can produce more accurate and more timely wind and temperature forecasts for air traffic management. WAFTAGE works best when either NWP forecast errors are large, in which case a small number of recent, site-specific observations can have a significant impact; or when there is a very high density of recent, site-specific observations, such as along flight paths in airport terminal areas.

References

1. Forrester, D.A., Davis, A.K., Coiffer, J., Hello, G. and Underwood, D.C. "The Improvement of Meteorological Data for Air Traffic Management Purposes", Stage 2b Report for Eurocontrol, Contract no. C/1.184/HQ/PW/94, PHARE Programme Task TM 02, December 1994.
2. Forrester, D.A., Sanders, J.E. "A Weather Model Adapted to specific Approach Problems", Report to ARAMIS project, November 1996.

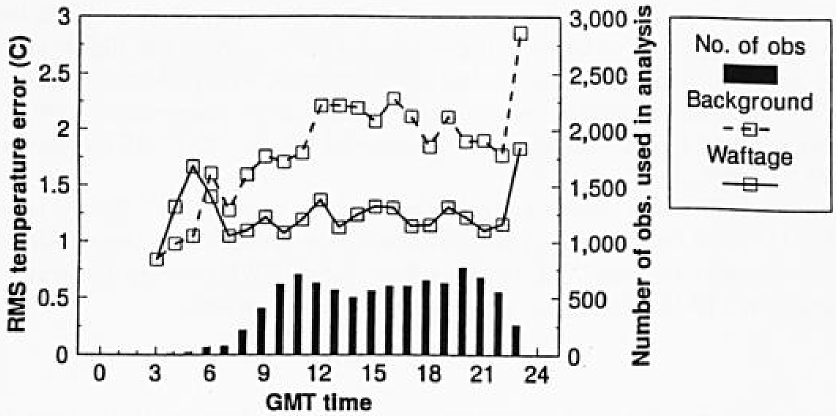

Figure 1. Comparison of temperature forecast errors for NWP and WAFTAGE over Europe during 24 hours on 9th February 1995.

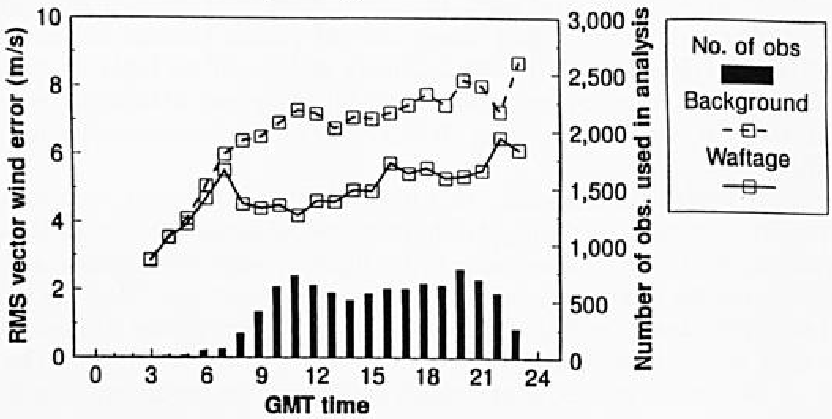

Figure 2. Comparison of wind forecast errors for NWP and WAFTAGE over Europe during 24 hours on 9th February 1995.

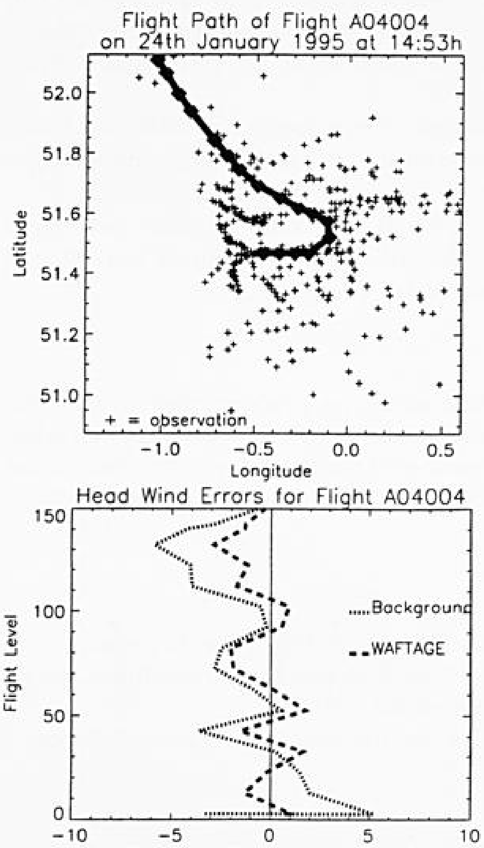

Figure 3. Example of WAFTAGE and NWP headwind forecast errors for a single flight.

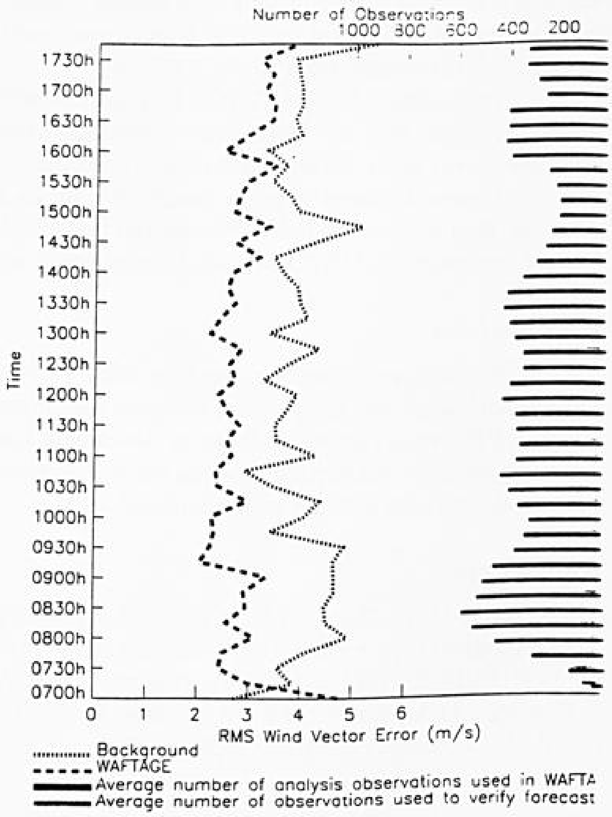

Figure 4. Comparison of wind forecast errors for NWP and WAFTAGE in the Heathrow terminal area during 11 hours on 24th January 1995.

ONBOARD WEATHER SYSTEMS FOR MARINE APPLICATIONS

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INTRODUCTION

The past few years has seen the development and introduction of onboard weather systems, both in the shipping industry and in the offshore oil and gas industry.

Although organisations such as Ocean Systems Inc., MeteoConsult BV and the UK Meteorological Office have developed similar systems, this paper will concentrate on the PC-based systems developed by Oceanroutes and now deployed widely throughout the above two industry sectors.

OCEANROUTES' ORION SYSTEM

Commercial shiprouting services have been provided for almost 50 years and are available today from a range of private companies and governmental agencies in Europe, North America and Japan. These services have varied little in approach, consisting of a route advisory message sent to the ship or the ship's agent prior to sailing and then updated as necessary during the course of the voyage.

Over the years, the practices in shiprouting services have developed and become more sophisticated. Services have become tailored to specific classes of vessels, operating at different speeds and with different operational constraints. The shore-based forecaster can offer advice and guidance to the Master but it is the Master's decision whether to accept that advice or to select an alternative route.

All strategic routing decision is taken on the bridge of the ship, and hence it seemed logical to put all the decision-making process on board, providing the Master with all the information necessary to select the optimum route for his vessel in terms of safety and overall economy.

With the assistance of acknowledged experts in the fields of ship motions, voyage optimisation and dynamical programming, Oceanroutes developed the ORION system (1). Following testing on a number of trans-Pacific and trans-Atlantic vessels the ORION system was launched operationally and today has been installed on over 200 vessels, including vessel types which do not normally make use of traditional shiprouting services.

The ORION system uses standard off-the-shelf hardware. The software is normally installed by and Oceanroutes' engineer who can ensure that the connection to the Inmarsat communications terminal has been made correctly and can provide the necessary training to shipboard staff. Subsequent software upgrades can be installed by ship's staff.

The meteorological data, made available twice daily for download by the ship consists of:-

Surface pressure charts
Wave charts
Wind charts
Current and ice data
Satellite imagery

The surface pressure charts, wave charts and wind charts give analyses and prognoses to T+240 hours, data for the major world currents is based on climatological values, and ice edge data is based on the most currently available information.

Prior to sailing, the ship will download the ORION environmental data. The Master or other member of the ship's crew is then required to enter the details of the voyage, ship details and any specific constraints. Once the details have been entered the ORION system calculates the best route to be followed, taking into account the constraints. The computed route is then displayed on a geographical background which can be overlaid with any of the meteorological parameters (fig 1). After the route optimisation has been computed, involving the calculation of "speed down", the Master can input alternative routes and ORION will compare these alternative routes with the optimised route, displaying the weather conditions along the alternative routes and the time taken. No matter which alternative route the Master chooses, it will not out-perform the route calculated by ORION.

Although in many cases the emphasis is very much on a least-time route it is also possible to optimise specifically for fuel consumption, total overall cost or scheduled arrival time (2).

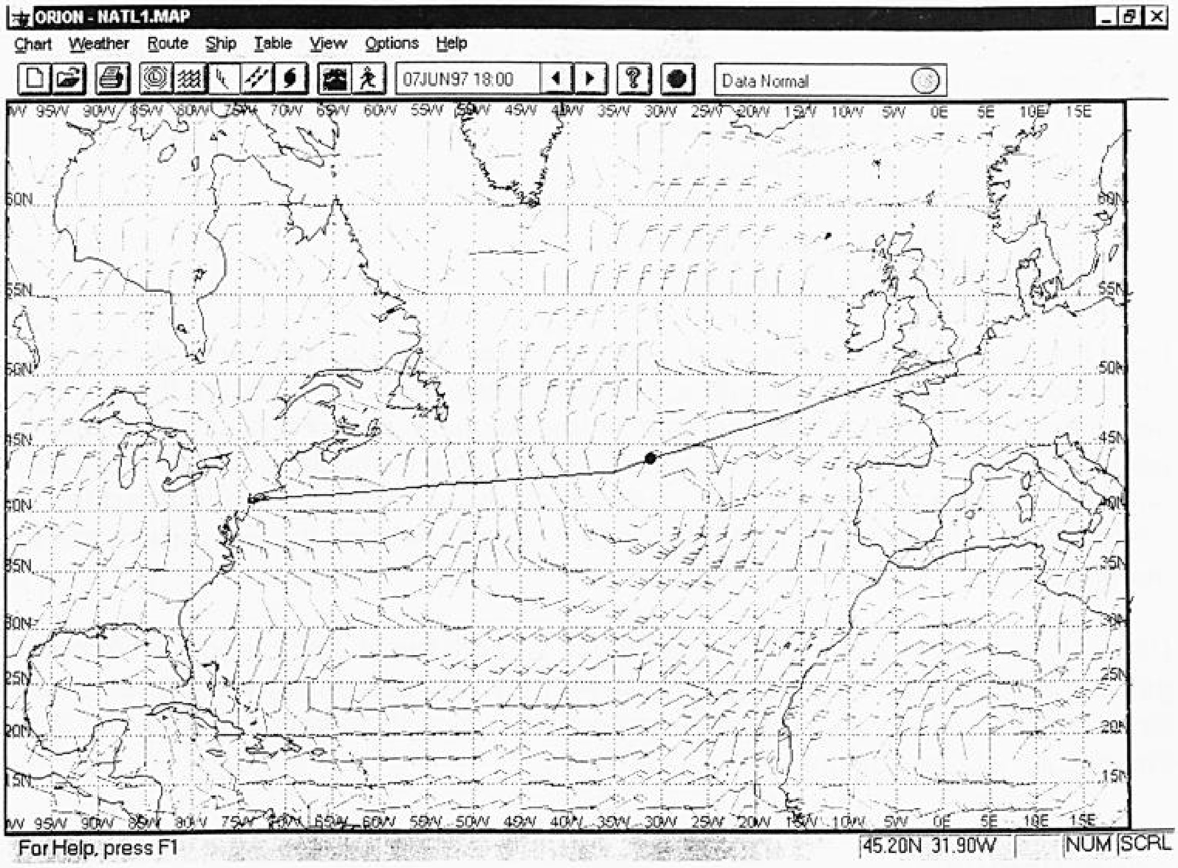
After each data download, the route can be re-optimised and any necessary course changes applied.

At the end of the voyage a detailed report can be printed out giving a complete history of the voyage.

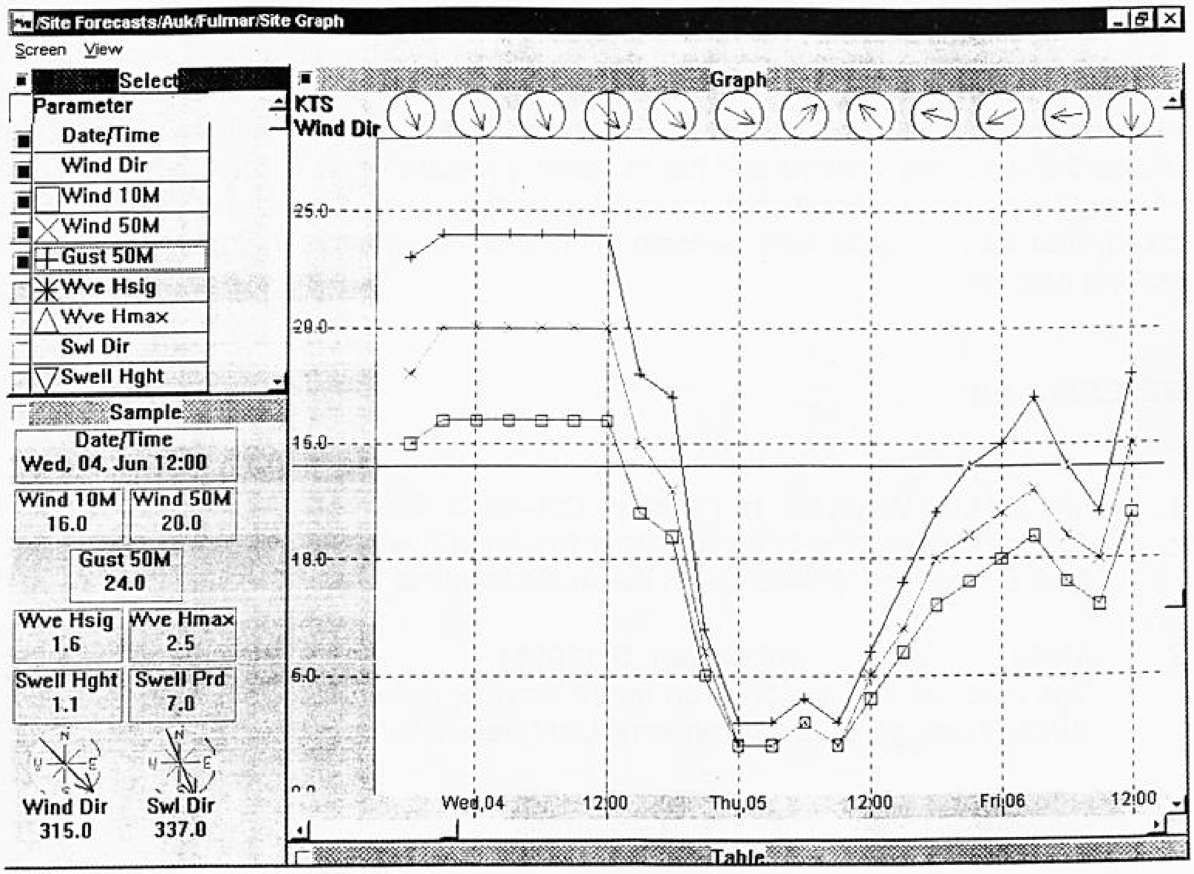
OCEANROUTES' SATURN SYSTEM

Whereas the ORION system is an interactive tool for the planning of ship routes, the SATURN system, designed specifically for the offshore oil and gas industry and for site-specific marine operations, is effectively a display system providing a graphical representation of forecast data allowing for easier and more accurate interpretation of predicted conditions.

As in the ORION system, SATURN uses standard off-the shelf hardware. The software is usually installed by and Oceanroutes' engineer with subsequent upgrades installed by the user.


ORION - NATL1.MAP
Chart Weather Route Ship Table View Options Help
07JUN97 18:00
Data Normal
For Help, press F1
45.20N 31.90W
NUM SCRL

(fig 1)


/Site Forecasts/Auk/Fulmar/Site Graph
Screen View
Select
Parameter
Date/Time
Wind Dir
Wind 10M
Wind 50M
Gust 50M
Wve Hsig
Wve Hmax
Swl Dir
Swell Hght
Sample
Date/Time
Wed, 04, Jun 12:00
Wind 10M 16.0
Wind 50M 20.0
Gust 50M 24.0
Wve Hsig 1.6
Wve Hmax 2.5
Swell Hght 1.1
Swell Prd 7.0
Wind Dir 315.0
Swl Dir 337.0
Graph
KTS
Wind Dir
25.0
20.0
15.0
10.0
5.0
Wed,04
12:00
Thu,05
12:00
Fri,06
12:00
Table

(fig 2)

Products available to the user include:-

- Surface pressure analyses and prognoses
- Wind analyses and prognoses
- Wave analyses and prognoses
- Text and time series site-specific forecasts
- Aviation data (TAFs and METARs)
- Satellite imagery (on request)

From the user's viewpoint the most useful and important elements are the time series of wind and wave forecast parameters, normally presented to T+72 hours (fig 2). These time series permit the offshore decision maker to determine quickly and unequivocally those periods when a weather window exists during which a particular operation may be carried out. This is seen as a significant improvement on the traditional text forecast the interpretation of which is at times dependent on the user and the work which has to be performed.

Other systems available in the market today for both the shipping and the offshore oil and gas industries are broadly similar. However they vary in terms of weather data range, in terms of marine and naval architecture and in the overall content and how that is tailored to the specific industry sector.

CONCLUSIONS

While it has not generally been the role of the forecaster to make operational decisions (e.g. whether flying operations can be carried out or whether an airfield should be closed) there is in the commercial field an increasing requirement from the user for enhanced information and better tools with which to make his operational decision. The success of onboard shiprouting systems and the increasing requirements of the offshore oil and gas industry for better presentation of forecast data at the decision making point indicate clearly that such systems have become integral components of the operational decision making process.

REFERENCES:

1. Motte, R.H., Wojdylak, H; Fazal, R; Calvert, S; Epshteyn, M; (1993)
   A Computerised On-board Weather Routeing System.
   First European Conference on the Applications of Meteorology.

2. Motte, R; Evans, J; and Calvert, S; (1995)
   The practical application of on-board weather routeing.
   RINA Proceedings of International Conference on Seakeeping and Weather.

Use of Contingent Valuation in the Assessment of Weather Information Delivery Systems

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ABSTRACT

The economic value of most traded goods is represented by the prices consumers are willing to pay for them in competitive markets. Most public goods such as access to weather information are not traded commodities and market prices are not available for use as measures of their economic value. In the absence of competitive markets, we must turn to alternative methods to estimate economic value in order to determine whether the investment made on the public's behalf to sustain these services is warranted.

The contingent valuation method (CVM) elicits from a relevant sample population of the sector for which the study has been done, people's economic valuation of a non-marketed good, based on their responses to a carefully designed questionnaire. The questionnaire defines the precise nature of the good that is to be offered via a hypothetical market. Respondents are offered the opportunity to "purchase" the good using a cash valued payment vehicle, such as user fees, or some other payment method. Ranges of offer amounts are used over the survey sample to develop a data set from which one can derive a statistical estimate of individual maximum willingness-to-pay (WTP). Individual WTP can then be aggregated to approximate measures of welfare changes of the relevant population or sector, due to provision of the non-marketed good.

Application of CVM Techniques

The CVM approach was used to assess two weather information delivery systems in Canada. These were the pre-recorded weather information service accessible to the Toronto local calling area commercial sector through Automated Telephone Answering Devices (ATAD), and Weatheradio broadcasts to the Maritime Community in Atlantic Canada.

These studies were designed to investigate at what dollar amount specific sectors of the economy or Canadian society would be prepared to support, through a user-pay approach, two individual but different programs to access weather information (pre-recorded weather information accessible through Automated Telephone Answering Devices - ATADs, and Weatheradio broadcasts to the Marine Community in Atlantic Canada). The alternative presented was the removal of these access services. The surveys were administered by phone with professional interviewers of a public opinion research firm. These studies used a referendum as a hypothetical market, in which a majority rule criterion applied. Each respondent was told that a majority "yes" vote would cost them a given dollar amount "P" per call in the ATAD case or a given dollar amount "P" annually attached as a maintenance fee to their maritime-related licence, certificate or registration form in the Weatheradio case. A majority "no" vote would mean that the program would be discontinued, and no one would be charged. Respondents were asked to cast their vote based on the value of the program to them relative to the amount they would be charged in the event of a majority "yes" vote.

In the ATAD case the question as stated by the interviewer to the respondent was:
Imagine that the Environment Canada Weather Line was available only on a pay-per-call basis. If each phone call to the Weather Line cost your company $P, would your company still phone the Weather Line during those months when your company uses the Weather Line most often?

In the Weatheradio case the question as stated by the interviewer to the respondent was:

If a majority voted YES, an annual maintenance fee would be collected from everyone holding a maritime-related licence, certificate or registration form. If the majority voted NO, nobody would pay the Weatheradio Canada maintenance fee and the Weatheradio Canada broadcasts would be eliminated. Would you vote for or against the proposal if the Weatheradio Canada maintenance fee to you was $P per year for the indefinite future.

In addition to these questions, significant detail was provided to the respondent to ensure a clear understanding of the specific service at issue and currently available alternatives to those services. Also other socio-demographic information was obtained from each respondent.

This types of binary response CVM question format is known as dichotomous choice (DC). The DC referendum format is preferred because strategic response bias is mitigated. In addition, these studies used a double-bounded technique to increase the statistical efficiency of resulting WTP estimates.

Consistent with utility maximization theory, WTP corresponds with the expected benefit the consumer would receive from the purchase of the good or service. It is assumed that a "yes" response to an offer amount $ P indicates that $ P ≤ the consumer's maximum WTP. We would also expect that the respondent would support any other bid less than $ P if he/she supports $ P.

These studies used a double-bounded logit model. This means that a second question was asked of each respondent, conditional on their response to the first. In the case of a "yes" response to the first question, the individual was then asked if he/she would pay a second, higher amount, $ P^h for the program. If the response to $ P^h is "no", we can conclude that $ P^h > maximum WTP. If the response to $ P^h is "yes" then it is assumed that $ P^h ≤ maximum WTP. In the case of a "no" response to the initial offer amount, a second lower amount, $ P^L is offered. If the second response is "yes", then it is concluded that $ P ≥ maximum WTP > $ P^L. If the second response is "no", then it is concluded that $ P^L > maximum WTP.

WTP is generally assumed to be distributed logistically. If $ P is close to zero, fewer people are likely to respond "no" and the probability of a "yes" response is high. As $ P gets larger, the probability of a "yes" response declines, and asymptotically approaches a lower bound. Since it is assumed that a "yes" to any amount implies that an individual would vote "yes" to any lower amount, the probability distribution of a "yes" traces out a cumulative density function (cdf). A property of a cdf is that its expected value is the area under it. Thus, the mean WTP for the ATAD program or the Weatheradio program is measured as the area under the estimated cumulative density function for WTP. The mean WTP can then be aggregated over the population of the sector for which the study has been done for an estimate of the total value of the ATAD or Weatheradio program for that sector.

Survey Development, Pretesting and Piloting

In both cases the survey development proceeded interactively through the course of several rounds of pretesting. During early stages, the description of the ATAD or Weatheradio program was developed to ensure that respondents understood the good and the payment vehicle. The first phase of the experiment included an open-ended pre-test which yielded a prior estimate of the WTP distribution. This distribution was used to generate bid amounts for a double-bounded dichotomous choice pilot survey. The pilot survey results were then utilized to develop the bids for the formal administration of the surveys.

The final version of both the ATAD and the Weatheradio surveys were incorporated into specifically contracted surveys administered during June, 1995 and March, 1996 respectively. The ATAD survey was administered by intercepting calls made by individuals to the recorded telephone message services with a total of 1300 respondants from commercial businesses self-selected in the Greater Toronto Area as participants in the survey. The Weatheradio survey achieved a sample size of 621 using a combination of random digit dialing and client lists to identify individuals in maritime related businesses in Atlantic Canada.

Estimating Willingness-to-Pay

The logistic cumulative density function of individuals' WTP is written as:

$$(1) \qquad G(P) = [\ 1 + e^{-(\alpha+\Sigma\beta X)}]^{-1}$$

where α and β are parameters to be estimated, and X is a matrix of bids and socio-demographic characteristics of the surveyed population, such as education, income, location and type of water supply.

For the ATAD survey the initial bid amount for each interview was selected randomly from the set of values S = [$1, $2, $3]. For the Weatheradio survey, since the recreational maritime community showed significant differences from the commercial maritime community during pilot testing the difference sets of opening bids were utilized. The initial bid amount for each interview was selected randomly as follows from the set of values S = [$20, $30, $50, $70, $80, $100, $150, $200, $250, $300] for the commercial community and from the set of values S = [$5, $9, $15, $20, $30, $60, $85, $110, $130] for the recreational community These sets of values were used because they span the means of the distribution for WTP, as determined through open-ended pretesting and pilot studies.

If the individual responded "yes" to $ P. a second higher bid P^h was selected from S. If the individual responded "no" to P, a second, lower bid from P^L, was selected from S. The process yielded a set of qualitative dependent variables:

"yes-yes" if the respondent said "yes" to P and P^h
"yes-no" if the respondent supported P but rejected P^h,
"no-no" if the respondent rejected P and P^L, and
"no-yes" if the respondent rejected P but supported P^L.

Using this vector of dependent variables and the matrix of bid amounts and other socio-demographic variables (X), the parameters of equation (1) were estimated with the maximum likelihood estimator, using the algorithm developed by Cooper, (1993). WTP is determined by the resulting distribution of positive responses to the bids. Socio-demographic variables that show significant variation with WTP indicate that people who share those characteristics may be more or less likely to have voted yes, on average. For both studies confidence intervals for the 95% level were estimated using the method of Krinsky and Robb (Park et al, 1991)

For the Toronto based ATAD study the WTP estimates and mediums coming out of the model for the entire Toronto local calling area commercial population and individual sectors are shown below.

Sector	WTP	Medium
Entire Sample	$1.003	$1.002
Construction	$0.974	$0.978
Landscaping	$1.076	$1.090
Film/TV/Photo	$1.337	$1.351
Agriculture	$2.135	$2.144
Leisure	$1.053	$1.067

For the Weatheradio study the WTP was $84.39 per Atlantic Canada individual involved in marine activities. These individuals include those involved in marine activities as a means of earning a livelihood as well as those who pursue marine recreational activities. The study showed that those who pursue marine recreational activities valued the Weatheradio service significantly less (at $47.10) than those who earn at least part of their livelihood through marine activities ($103.28). Indeed the 95% confidence interval for the recreational mariner is totally below that of the commercial mariner.

AGROMET-ONLINE, AN AGROMETEOROLOGICAL PLANNING AID FOR THE FARMER

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ABSTRACT

As in commerce and industry the rationalization and centralization process is also advancing in agriculture: increasingly larger areas of farmland are being cultivated by ever decreasing numbers of people and more efficient machines. This requires intensive and elaborate planning. Modern harvest machines have in part become so sophisticated that they can be used for mapping yield or controlling the locations and states of the machines from a central control point. Knowledge of the expected weather development helps optimize planning processes, which in the end are reflected in the economic success of a business. Agriculture, therefore, has a large interest in the longest-term and most exact weather forecasts possible, as well as informations about the expected conditions at the production sites.

The DWD has faced this large and almost insolvable problem and, together with agricultural machinery manufacturer CLAAS, has developed the AGROMET-Online advisory product. Both cooperation partners are aware that the extensive demands of the farmers regarding exactness of the forecasts cannot be fulfilled. With the aim of providing the best and most helpful advisory product possible under these restrictive conditions, AGROMET-Online was designed, whereby its entire contents are supplied by the DWD and the layout and data management developed by the CLAAS company.

The customers are provided with the prognoses twice a day, with the forecasts containing a general weather forecast text for the region concerned as well as general local weather and agrometeorological forecasts in the form of numbers and diagrams. If required each customer can receive the radar pictures in a temporal resolution of 15 minutes and evaluate these by zoom and loop functions. Twice a day the complete model chain of the DWD, up to the 7th forecast day, is used for the forecast values. In addition the prognoses for the first three days undergo a Kalmann filtering and their coefficients interpolated on the site given. From the fourth forecast day, only the most favourable grid point of the global model, including a temperature correction, is used. The elements air temperature, wind speed and relative humidity are presented in graphic form for the first three forecast days in a temporal resolution of one hour and after that, as for precipitation, in six hours. In addition diurnal values of the maximum and minimum air temperatures, duration of sunshine, precipitation, the actual evaporation as well as a pictogram are presented in tabular form.

These general forecast values give the farmer a rough overview of the weather to be expected, but not specific information as to the use of pesticide spraying or the time for planting or harvesting, because no information is yet available on the state of plants and soil resulting from the future weather. For this reason some agrometeorological models that were developed at the Agrometeorological Research Institute in Braunschweig and proved in daily advisory are calculated with the forecast values of the site. Each customer can choose a specific plant, such

as grassland, winter wheat, maize, sugar beets, summer barley, winter rape, rye or oats, for which specific crop quantities are calculated. The actual plant development condition, described by the leaf area indice, the root depth and the canopy height are calculated indirectly by means of messured phenological plant phases are regarded in the models. Further, all soil processes are calculated with the characteristic quantities of the type of soil found at the site. Apart from the specific plant quantities such as crop temperature and period of leaf wetness, specific soil quantities such as soil surface temperature, soil temperatures at a depth of 5 and 20 cm, as well as mean soil moisture in the upper 5 and 60 cm, are calculated. With the exception of the soil moisture of the upper 60 cm calculated as diurnal value, all quantities are given out in a temporal resolution of one hour. As the effectiveness of pesticide spraying is often dependent upon temperatures and humidity in the crops, soil moisture in the root region, as well as precipitation after application, the time for certain work processes can be determined better with the characteristic agrometeorological quantities supplied. The date for planting is mainly dependent on soil moisture and temperature of the upper layers and the further course of the weather. Here, too, the characteristic quantities provided help in making decisions. The characteristic quantities described can be used by the farmer for various work processes during the whole period of plant development, whereby, however, the interpretation of each combination is left up to the farmer.

A further contribution allows a better estimation of the optimal harvest time for grain and grass. Starting from three different initial humidities in harvested crops, the future course of the grain moisture is predicted, whereby it is assumed that the grain is ripe at the beginning of the simulation. The farmer knows when the grain is ripe and can easily estimate or measure the grain moisture content, so that he can take the relevant simulation into account when making his decisions. The farmer's aim here is to harvest the grain in the situation given with the least possible moisture content in order to avoid expensive drying necessary for storability. The simulation of the drying behaviour of cut grass is more difficult, as the farmer has a great influence over this process indirectly by frequent turning. On the other hand, each farmer cuts his grass at different intervals in the year, which in turn determines the particular grass mass to be dried. For this reason, compared to the grain moisture calculation, a total of three simulations for the drying behaviour of the grass are carried out, which assume that the grass is cut in the early morning. The simulations are carried out for three varying total masses so that the farmer must decide whether he has a cut mass which is average, above or below. In the simulations turning was done only after precipitation occurred, when the lower grass layers have become very moist. When the farmer turns frequently, the drying behaviour improves in comparison with the simulation, but he must pay for this with higher operation costs. With the help of the simulated drying degree of the grass, the farmer can ascertain when the silage or the hay can be brought in.

In order for the farmer not to be confined to his locality from which until now no original measured meteorological values flow into the calculation, all described quantities for three neighbouring Synop stations, where originally measured values have flowed into the calculations, are also provided.

In order to be able to keep costs down to an acceptable level, all products are supplied fully automatically without specific individual control. At the beginning this caused considerable organizational problems, because the information required is produced in different departments within the DWD. Meanwhile, the provision of data/products is generally stable.

To prevent too large a discrepancy occurring between the wishful notions of the farmer and that which is feasible at the moment, each new customer is provided with background information and also offered a training course in which the origin and quality of a forecast as well as the agrometeorological models and their interpretation are explained. AGROMET-Online provides the possibility to act on prognoses of the past and so allows an qualitativ valuation of the aktual prognose.

This advice package has been on offer since spring 1996. Up to the present response has been varied. Especially those customers, who have been using the new product for a longer period and know the difficulties and inadequacies of a forecast, are mainly satisfied and partly have prognoses calculated for different sites. Up to now, after the first year we have lost only 5% of the customers, which can indirectly give cause for content. The CLAAS company would also like to offer this advice package abroad. A test operation is planned for France in 1997 in collaboration with METEO-France, DWD and CLAAS.

(INT\Ecam-adr\A-Janssen)

FOREST FIRE FIGHTING METEOROLOGICAL AID IN THE VALENCIAN COMMUNITY: PIF-GPVV INDEX

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INTRODUCTION

The Valencian Community, which is located in the east of the Iberian Peninsula on the Mediterranean coast, extends over 2,200,000 Ha. of which 1,200,000 are forests.

Analysis of its forest fires shows that meteorological conditions represent a decisive factor in both the start of fires and in their subsequent propagation.

In view of this, meteorological support has been provided for forest fire fighting since the late eighties. By 1993 this support had taken the form of the PIF-GPVV Index, the objective being to establish a list of the meteorological factors that were most directly useful for indicating on which days fires could become most widespread. For this purpose, index levels were set which gave useful results for the firefighting organisations.

The index is adapted to Mediterranean meteorological conditions in general and to the special characteristics of the Community of Valencia. Prediction is not complicated as long as the predictor applies meso-scale concepts and has sufficient knowledge of the behaviour of the parameters to be predicted at local level.

Fires causing extensive devastation appear on a very small number of days. The results of the index show that indication of the days on which such serious fires appear is high, greater than initial expectations for user utility. For this reason, daily announcement of the index is decisive in enabling fire-fighting organisations to adopt appropriate measures.

Operational application has been in force since the summer of 1993 in the Community of Valencia, with the index levels being produced on a daily basis for the day of announcement and the following day. At the request of the authorities of the Community of Murcia, the neighbouring region, this year the system has been applied there too.

BASIS OF THE INDEX

In order to determine the link between the extension of fires and meteorological conditions, a statistical calculation was carried out in order to quantify the effect of each of the latter on the seriousness of fires. As a result of the study, the parameters selected for inclusion in the index are:

Type of wind circulation
Maximum wind speed
Minimum relative humidity
Maximum temperature
Registered rainfall and evaporation of rain
State of vegetation
Predominant relief

The contribution of the parameters varies, and a clear difference is established depending on the type of circulation. This leads to two types of formula: land (marked circulation of wind and low humidity) and non-land (the remaining cases).

The index varies between 0 and 100, giving three risk or alert levels, and these can be used for operative purposes by the fire-fighting organisations. The minimum level is Alert 1, medium is Alert 2 and maximum is Alert 3.

DESCRIPTION OF OPERATIONAL SUPPORT

For operational use of the Index, the Valencian Community was divided into 7 areas according to criteria of meteorological homogeneity, mainly taking into account wind and the maritime influence. In each of the areas a representative automatic station was chosen from those carrying out predictions on the above meteorological parameters. The prediction of these parameters at ground level requires great skill as without the added value of the predictor on prediction patterns it would be difficult to achieve the desired results. By way of additional information, the risk of storms with low levels of precipitation is also carried out for each area.

These predictions are carried out for the day itself and for the following day and the reports are duly transmitted to the organisations concerned.

RESULTS

Below are some overall results for 1993, 1994 and 1995 for the most critical period from 1 June to 30 September (between 15 June and 30 September in the case of 1993), this being the period of the 'PREVIFOC' fire prevention campaign. The period from July 2 to 7 1994 is not included, due to the extraordinary meteorological conditions that provoked a 3 level of forecast alert, having caused 47 fires and a total of 102.000 Has. burnt.

	No.DAYS	No.FIRES	SURFAC	FIR/DAY	SUR/DAY	SUR/FIRE
ALERT-1	249	506	2113	2,0	8,5	4,2
ALERT-2	69	296	4766	4,3	69,4	16,1
ALERT-3	29	198	46495	6,9	1619,2	234,8

TABLE no. 1.- Link between alert warnings and fires. ALERT: Type of alert warning. No. DAYS: Number of days of each type. No. FIRES: Number of fires per type of alert. SURFAC: Total surface area burnt in hectares. FIR/DAY: Number of fires per day. SUR/DAY: Surface area burnt per day. SUR/FIRE: Surface area burnt per fire.

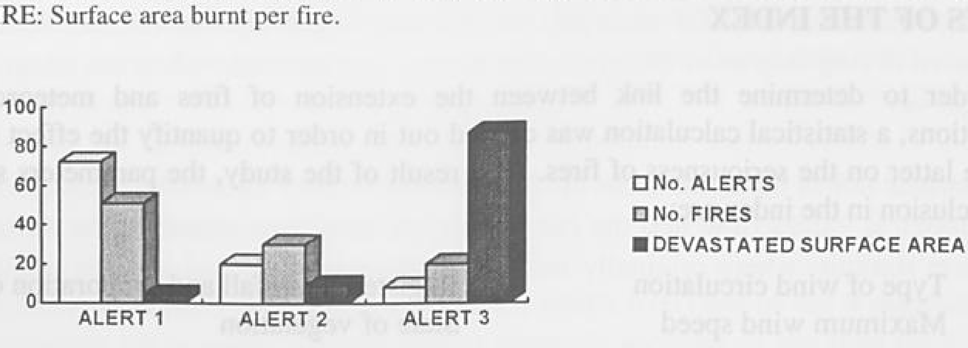


Figure no. 1.- Distribution in percentages of the number of alerts, the number of fires and the devastated surface area.

Over 70% of days were at alert 1 level (minimum) in the predictions and on these days less than 4 % of the total devastated surface area was burnt. The number of days at alert 3 level (maximum) was not more than 10% of the total, and about 87% of the total devastated surface areas was burnt on these days. It can also be seen that the number of fires per day (FIR/DAY) recorded practically doubled as the alert level rose.

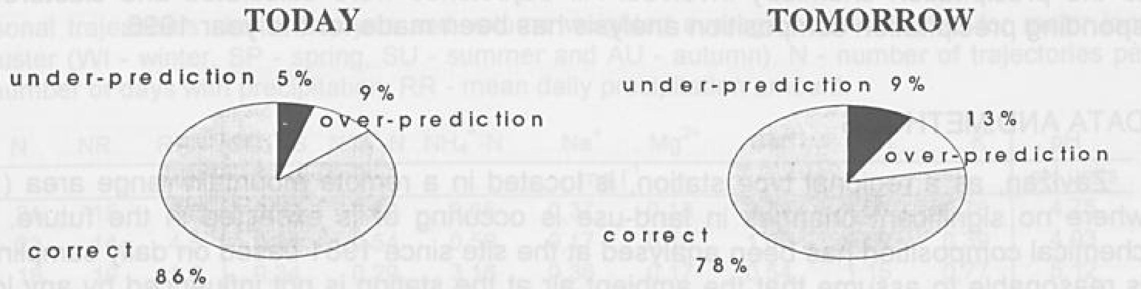
The following table shows the number of fires in terms of hectares affected and the alert level (years 91-95).

	<1 Ha	1/5 Has	5/50 Has	50/100 Has	100/500 Has	500/1000 Has	> 1000 Has
ALERT-1	326	203	85	9	7	0	0
ALERT-2	367	218	91	10	17	1	1
ALERT_3	211	152	71	23	27	8	41

TABLE no. 2.- No. fires in terms of hectares affected and the alert level (years 91/95).

This shows how the large fires took place on days on which the alert level was at level 3, except for a couple of fires of over 500 Hectares at level 2.

In order to evaluate the predictions, an analysis was carried out of the alerts given and of the alerts which correspond to the actual data for each area. The percentages for 1994 are shown over the critical period for the day itself and for the following day.



Figs. 2 and 3.- Percentage of correct alarms, under-predictions and over-predictions.

The above shows that the proportion of correct predictions is very high and that the proportion of over-predictions is slightly larger than the under-predictions. The values are very acceptable and confirm that predictions are correct, with same-day predictions obviously being better than those for the following day.

The efficiency of the index and of the processes required for offering meteorological support is clear from the high degree of discrimination given by the alerts for the burnt surface area and the number of fires.

CONCLUSIONS

The PIF-GPVV index shows a high discrimination of the net risk for the propagation of forest fires with a high degree of predictability, provided that the predictor is sufficiently well-trained in the meso-scale characteristics of the prediction area, and is a very useful tool for fire-fighting organisations.

AIR TRAJECTORIES ANALYSIS FOR ENVIRONMENTAL APPLICATIONS

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INTRODUCTION

Meteorological Services serve very often as centres of activity for the provision of specialized meteorological assistance in the cases of large release of hazardous material into the atmosphere, nuclear or industrial accidents or for regulatory envoronmental applications. A flexible environmental modeling system has to be developed in order to provide decision support tools directly used either by Governmental bodies or institutions engaged in a wide variety of environmental and air quality assessment studies, research activities and regulatory applications.

A number of methods have been used in order to evaluate the transport of pollutants from the source to the deposition region. The most used one is the single back-trajectory method that enables interpretation of source-receptor relationships at a given point as well as the chemical composition of the atmosphere along the trajectory path.

The complexity of circulation patterns in pre-Alpine regions introduce a lot of difficulties in analysing meteorological conditions that affect transport and deposition of pollutants to these regions. In order to learn more about these processes in this study, single back-trajectory method was used for two purposes: to analyse atmospheric transport paths to the EMEP site Zavižan and to relate them to the precipitation chemistry involved. Air trajectories were calculated and clustered and corresponding precipitation composition analysis has been made for the year 1996.

DATA AND METHODS

Zavižan, as a regional type station, is located in a remote mountain range area (1594 m asl.) where no significant changes in land-use is occuring or is expected in the future. Precipitation chemical composition has been analysed at the site since 1981 based on daily sampling protocol. It is reasonable to assume that the ambient air at the station is not influenced by any local pollution and contains only diluted vestiges of chemical compounds coming to the site by mainly transboundary and long-range transport.

To study atmospheric transport to Zavižan, three-dimensional 96-h backward isentropic trajectories were computed once a day for the period January - December 1996 at the end point of 10 m asl. over site. The Hybrid Single-Particle Lagrangian Integrated Trajectories Model (HY-SPLIT, Draxler, 1992) with a 1-h advection time and gridded meteorological data fields (NCEP Nested Grid Model) has been used for this purpose.

In order to group air trajectories that indicate similar meteorology, trajectories are clustered for each season. The cluster variables are the trajectories endpoints represented by wind speed and direction (Stunder, 1996). Given N trajectories are each initially defined as a separate cluster with zero spatial variance. Cluster spatial variance is the sum of the squared distances between the endpoints of the cluster's component trajectories and their (cluster) mean. Successive steps through clustering process combine the two clusters that result in the minimum increase in total space variance (TSV), where TSV is the sum of all the cluster spatial variances. The combining continues until all trajectories have been merged into signifficantly different clusters.

After significant transport sectors for each season have been identified, volume weighted concentrations of major ions in precipitation are calculated for each cluster and for each season. In order to select important transport routes, related pollution levels, and their signifficance with regard to the identification of major pollution source regions, mean volume weighted seasonal concentrations for clustered and unclustered data sets are compared.

RESULTS

Cluster analysis results in five cluster-mean trajectories for each season. Generally, each cluster contains comparatively long (fast) or short (slow) trajectories oriented in a given direction and indicates major weather types in the region (Figure 1):

a) fast W-NW flow connected with frontal passages (WI4, SP2, SU5, AU5);
b) strong SW flow as a part of cyclonic circulation with center over Genoa Bay (WI5, SP5, SU2, AU4);
c) N-NE flow as a part of anticyclonic system over west or central Europe (WI2, SP3, SU3, AU2);
d) S-SE flow along the Adriatic coast (WI3, SP4, SU4, AU3) and
e) very short trajectories connected with stationary northern Adriatic cyclogenesis, predominantly in spring (WI1, SP1, SU1, AU1).

Concentration values, calculated for each cluster within the season, season as a whole, and mean annual values are given in Table 1. According to results obtained there are two major transport routes to the region that bring higher levels of acidifying compounds. One, from the NW wind sector can be devided into slow and fast trajectories (Fig. 1). Fast trajectories are connected with higher levels of sulphate and nitrate concentrations, especially in autumn and spring. Slow trajectories, seem to influence and decrease pH value. The critical season is apparently Spring, when pH values are around 4.5 for the air and precipitation coming from three sectors (NW, NE ans SE). At the same time mean sulphate and nitrate concentrations meet their highest values, as seasonal mean and maximum. Similar conclusions may be derived for the Autumn. Winter season at Zavižan is characterised with precipitation in a form of snow, hence it seams that deposition of sulphates is slightly lower then in other seasons. SE and NE wind sectors are identified as ones from where higher concentration levels can be expected in all seasons. Analysis for the whole period with regard to trajectories coming from 8 major wind sectors are given in Table 2.

Table 1. Seasonal trajecotries cluster analysis and volume weighted average concentrations for major ions and pH per cluster (WI - winter, SP - spring, SU - summer and AU - autumn). N - number of trajectories per cluster; NR - number of days with precipitation; RR - mean daily precipitation amount.

CLUSTER	N	NR	RR	$SO_4^{=}$-S	NO_3^--N	NH_4^+-N	Na^+	Mg^{2+}	Ca^{2+}	Cl^-	K^+	pH
			mm	mg l^{-1}								pH units
WI1	31	15	5,8	0,37	0,62	0,65	0,37	0,18	0,78	1,06	0,78	4,75
WI2	23	14	4,5	0,34	0,54	0,59	0,17	0,18	1,00	0,69	0,39	4,93
WI3	18	10	11,6	0,34	0,29	3,16	0,36	0,17	0,54	1,15	0,77	5,12
WI4	11	4	15,7	0,15	0,45	0,51	1,63	0,26	0,69	2,25	0,61	5,31
WI5	8	7	20,9	0,30	0,24	0,15	0,18	0,15	0,49	0,68	0,12	5,80
WI mean		***50***	***11,4***	***0,34***	***0,41***	***1,08***	***0,48***	***0,19***	***0,74***	***1,19***	***0,72***	***5,08***
SP1	47	22	10,9	0,62	0,54	0,50	0,36	0,21	0,90	0,67	0,28	4,59
SP2	13	3	0,2	0,24	1,21	1,03	0,30	0,24	1,49	1,15	0,50	6,57
SP3	13	6	1,7	2,19	1,28	1,54	0,51	0,34	1,54	1,91	0,55	4,80
SP4	14	8	8,8	0,76	0,46	0,54	0,65	0,34	1,95	1,13	0,54	4,40
SP5	5	2	15,5	0,09	0,19	0,29	0,42	0,17	0,58	0,67	0,00	5,97
SP mean		***41***	***9,9***	***0,61***	***0,50***	***0,51***	***0,42***	***0,23***	***1,11***	***0,81***	***0,32***	***4,60***
SU1	27	6	5,1	0,49	0,44	0,50	0,31	0,39	1,18	1,10	0,24	6,21
SU2	23	12	16,3	0,36	0,45	0,51	0,88	0,31	1,06	1,89	0,43	5,96
SU3	14	3	14,1	0,23	0,18	0,35	0,26	0,25	1,38	0,93	0,39	6,60
SU4	14	8	16,6	0,57	0,55	0,57	0,51	0,37	1,48	1,18	0,31	6,23
SU5	9	3	1,0	0,81	0,89	0,18	0,79	0,98	4,13	1,53	0,81	6,82
SU mean		***32***	***12,9***	***0,43***	***0,45***	***0,51***	***0,65***	***0,34***	***1,26***	***1,49***	***0,37***	***6,10***
AU1	38	24	9,3	0.25	0.35	0.24	0.26	0.13	0.64	0.68	0.29	4,89
AU2	9	5	7,6	0.83	0.53	0.44	0.23	0.18	0.58	0.32	0.30	5,39
AU3	22	17	20,8	0.46	0.28	0.36	0.57	0.28	0.90	0.84	0.30	5,20
AU4	16	11	23,7	0.60	0.60	0.46	1.16	0.35	0.98	1.55	0.38	5,09
AU5	4	2	9,8	0.17	0.21	0.15	1.11	0.29	0.48	2.13	0.20	6,57
AU mean		***59***	***15,6***	***0,43***	***0,36***	***0,33***	***0,60***	***0,24***	***0,77***	***0,94***	***0,29***	***5,12***
Annual mean		***182***	***11,6***	***0,44***	***0,42***	***0,56***	***0,55***	***0,25***	***0,92***	***1,07***	***0,37***	***5,02***

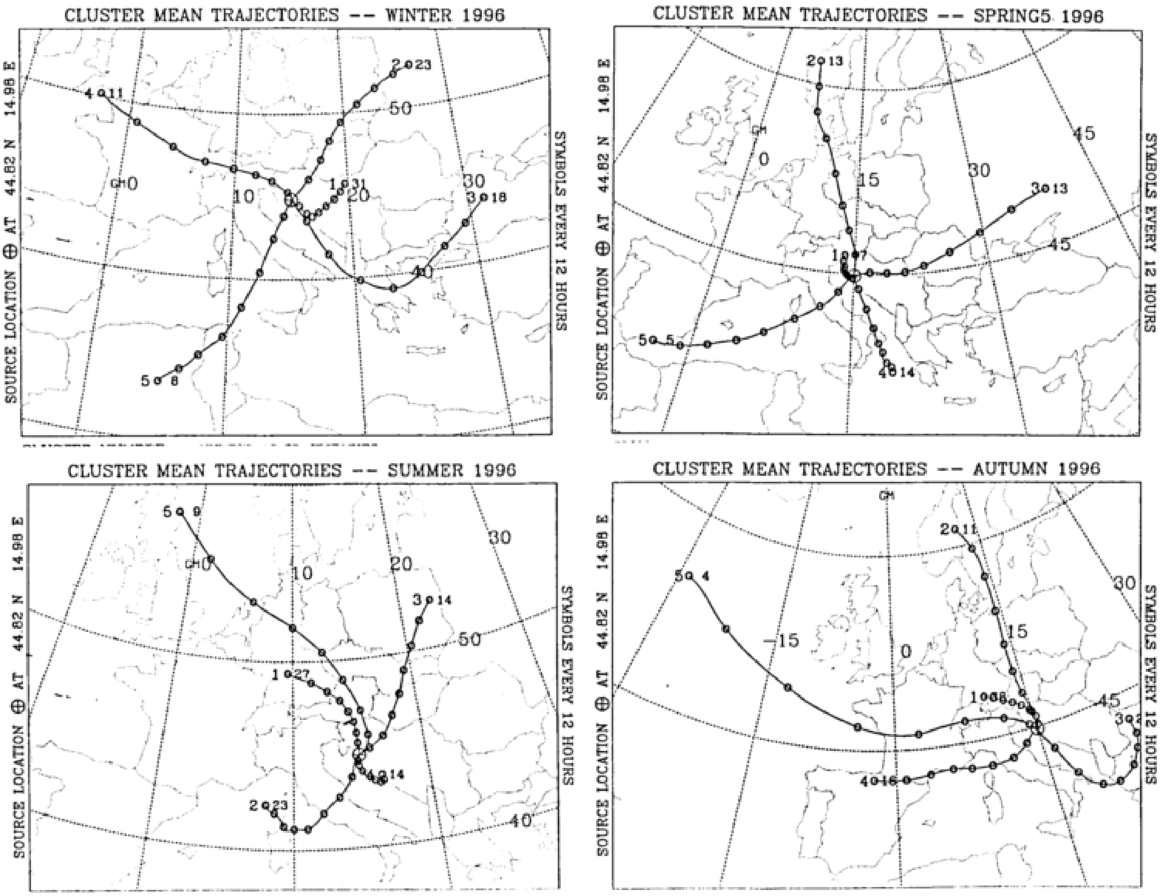

Figure 1. Cluster-mean trajectories for each season.

Sectorial mean concentration values where maximum concentrations and minimum pH values were observed are given in bold letters. Although indication for major transport patterns can be seen from sector analysis, trajectories clustering method enables more insight into both atmospheric processes and transport paths.

Table 2. Sectorial volume weighted concentrations of major ions and pH for the period Jan-Dec.1996

SECTOR		RR	$SO_4^{=}$-S	NO_3^--N	NH_4^+-N	Na^+	Mg^{2+}	Ca^{2+}	Cl^-	K^+	pH
(wind)		mm	mg l^{-1}								pH units
NNW	fast	104,6	0,41	0,49	0,47	1,08	0,25	0,74	1,51	0,50	5,35
	slow	493,9	0,45	0,45	0,38	0,31	0,19	0,19	0,80	0,69	**4,73**
WNW		38,1	0,17	0,21	0,15	1,11	0,29	0,48	2,13	0,20	6,57
WSW	-	-	-	-	-	-	-	-	-	-	-
SSW		610,1	0,41	0,43	0,38	**0,75**	0,27	0,87	**1,37**	0,30	5,44
SSE	fast	541,4	0,47	0,30	**0,94**	0,53	**0,26**	**0,94**	0,91	0,41	4,97
	slow	132,6	**0,57**	**0,55**	0,57	0,51	0,37	1,48	1,18	0,31	6,23
ESE	slow	110,5	0,33	0,52	0,59	0,34	0,17	0,73	1,02	**0,74**	4,82
ENE		10,3	2,00	1,17	**1,41**	0,46	0,31	1,40	1,74	**0,51**	4,84
NNE		105,7	0,39	0,55	0,66	0,25	0,26	1,43	0,98	0,50	**4,98**

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References:

Draxler, R., 1992: Hybrid single-particle Lagrangian integrated trajectories (HY-SPLIT)Version 4.0 Users guide.
Stunder, B., 1996: An Assessment of the Quality of Forecast Trajectories, J. Appl. Met., 35, No. 8, 1320-1331.

EXPERIENCES WITH THE ROAD WEATHER INFORMATION SYSTEM (SWIS)

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ABSTRACT

- What significance does the Road Weather Information System (SWIS) have for the road construction authorities in Baden-Württemberg

In order to be able to carry out fast and effective winter road service on the federal motorways, highways, main and secondary roads, reliable weather forecasts are required.

Up until 1995 there were no tailor-made road weather forecasts available for operational activities. The road operators responsible for organizing the winter service had to rely on radio reports and local weather observations. Weather stations with facilities for reporting ice were able to help out with a timely plan of action for a few of the larger bridges.

Before the 1995/1996 winter period began, all 21 motorway and 124 road operators in Baden-Württemberg were connected to the SWIS Road Weather Information System of the Deutscher Wetterdienst.

The following information is available via telefax:

- **a medium-range road weather forecast** with a forecast period of 3 days for the extent of the federal state,
- **a detailed regional road weather forecast** with a forecast period of 24 hours. The prognosis is aimed at small-scale climate areas and in addition differentiates according to height in 200 m intervals and
- **road weather warnings** which, if and when the need arises, describe "sudden" weather occurrences in a very concise form.

The data density on weather information was thus raised considerably for the road operators with the SWIS system.

- Decisive criteria for the introduction

The development of the SWIS Road Weather Information System was undertaken on the orders and under the expert guidance of the Federal Ministry of Transport at the Deutscher Wetterdienst in Offenbach. After successful trial runs the federal road construction authorities were asked to install the SWIS system. The costs for the original hard and software equipment including the conversion of existing weather stations were taken over by the Federal Ministry of Transport. No costs were charged for the provision of information between the departments of the Federation and those of the federal states.

Under these circumstances, the decision to introduce the new Road Weather Information System was easy for the federal state of Baden-Württemberg.

- **Financial and organizational consequences, experience gained in the first two winter periods**

Approximately 4 million D-Mark were spent in the federal state of Baden-Württemberg on the original equipment for the system, recurring costs for the transmission and switching of information and the maintenance of hard and software amount to approx. DM 200,000 annually. These costs must be seen in relation to the average expenditure for the winter service. In Baden-Württemberg, with a road network of ca. 26,000 km as well as 1,000 km of motorways, costs amount to between 50 and 70 million D-Mark annually, depending on the intensity of the winter period.

The experience gained with the Road Weather Information System for the planning of winter service operations is mainly rated as positive. The correlation between the prognosis and the occurring weather situation was rated as good on average and registered with an accuracy proportion of between 70 and 80%. Restrictions in the quality of the prognoses are reported for areas that are not equipped with weather stations such as, for example, the Swabian Mountains and the Lake Constance area. In such cases it may be necessary to install additional weather stations. A qualified cost/benefit examination is not possible with the present data situation. It is occasionally reported that the road weather information could have led to additional on call stand-by times. A quantification of additional expenditure is, however, not available.

In the beginning considerable problems occurred in the transmission of the weather reports from the SWIS headquarters to the road operators. They were faced with great problems in providing a telefax link to 124 offices, so that in isolated cases delays of up to 5 hours occurred, which, of course, clearly lowered the acceptance of the system. Unlike the motorway operations which are manned round the clock, the reception of the reports during the night-hours and at the weekends caused organizational difficulties with the road operators. In the meantime it has been decided that those responsible for the winter service operations should also be available at the weekend to receive warnings in critical weather situations. A special training course would be helpful in improving acceptance.

When seen as a whole, it can be established that, with the aid of the SWIS Road Weather Information System, the winter service can go into operation more promptly and better adapted to the situation. A monetary assessment of the business management and economic benefit is not possible due to the singular weather occurrences.

METEOROLOGY AND CIVIL DEFENSE : EFFICIENCY OF THE WARNINGS FOR SEVERE WEATHER EVENTS IN FRANCE

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ABSTRACT

Introduction

Since about seven years, Météo-France and the French Civil Defense have been cooperating in providing State representatives and local authorities with warning messages in case of severe weather events. Since three years they have been undertaking a systematic evaluation of the efficiency of these warnings. Various characteristics of the meteorological events as well as informations about the observed consequences, which are regularly collected, enable to evaluate the pertinency of the procedures.

General organization

The responsability of issuing meteorological warnings in case of severe weather over the national territory is one of the most very important duty for Météo-France. Seven Regional Forecast Offices (Lille, Strasbourg, Lyon, Aix-en-Provence, Bordeaux, Rennes and Paris) are responsible for issuing warnings within their own responsability area under the coordination of the Central Forecast Office, in Toulouse.

When typical meteorological parameters are expected to overstep several thresholds inside a french departement (administrative area covering approximately 5 000 km^2), so Regional Forecast Offices have to issue warnings (Regional Meteorological Warning Bulletins) toward the regional authorities in charge of the civil defense. Decision is taken after a discussion with the Chief Forecaster of the Central Forecast Office. When this latter thinks that the concerned geographical area is very important or the intensity exceptional, he may issue a special warning (National Meteorological Warning Bulletin) toward the national centre in charge of the civil defense. Of course this organization requires a close cooperation between forecasters at regional and national levels. Then Civil Defense Authorities forwards these messages to the State representatives and the emergency services in the 96 french departments.

Content of the warnings

The content of the warnings has to be clear enough to allow various intervenors to take decisions and to implement possible safety means. Therefore the presentation format of these messages is well defined and comprises : a sequence number, the identification of the meteorological event, its expected starting and termination time, a short text describing its evolution (emphasizing possible dangerous associated phenomena), the detailed list of the all the departements which could be affected and a few numerical characteristic values (like the expected intensity of the gusts or the rainfall heights). These warnings are regularly updated when new informations become available, in any case, once a day ; alarm termination is also notified by a special bulletin.

Evaluation of the warnings

Since three years both Météo-France and the French Civil Defense have been evaluating the efficiency of these procedures. National and regional offices issuing warnings have to prepare a short report describing the actual evolution of the meteorological phenomenon, namely the beginning of the significative event, its duration, the affected areas and the observed peak values for various parameters ; such informations, compared to the forecast ones, allow to assess the meteorological pertinency of the warning bulletins. Moreover, informations dealing with the observed consequences of the event (number of interventions, importance of the emergency actions, damages to the buildings, rescue operations, injured or died people) are collected by the Civil Defense. The treatment of these data allows to evaluate the global efficiency of the warning procedures. It is important to note also that a few meteorological events, having significant consequences without being announced by a warning, are also taken into account for this evaluation.

From 1994 to 1996, 414 regional warnings affecting several departments were issued by the Regional Forecast Offices before forecasted hazardous weather events, 24 of them following national warnings issued by the Central Forecasting Office. The occurrence of the hazardous events with respect to the geographical area and the type of phenomenon are given in the tables A and B below. It appears that a great number of warnings are issued for heavy precipitations and thunderstorms, espcially in the southern regions of France.

Table A : National warnings issued by the National Forecast Office from 1994 to 1996.

Phenomenon	Strong Winds	Heavy Precip.	Thunder-storms	Snow	Freezing Rain	Cold Outbreak	Avalan-ches	**Total**
National Warning	5	6	5	4	4	0	0	**24**

Table B : Regional warnings issued by the 7 Regional Forecast Offices from 1994 to 1996.

Reg. For. Office	Strong Winds	Heavy Précip.	Thunder-storms	Snow	Freezing rain	Cold Outbreak	Avalan-ches	**Total**
North	14	5	12	17	8	1	0	**57**
North-East	6	8	14	10	12	0	0	**50**
Centre-East	8	24	34	11	2	0	7	**86**
South-East	24	45	6	19	0	0	7	**101**
South-West	8	18	11	7	3	0	3	**50**
West	13	4	9	12	2	1	0	**41**
Centre	5	3	7	3	10	1	0	**29**
Total	**78**	**107**	**93**	**79**	**37**	**3**	**17**	**414**

Results and conclusions

Global results about the efficiency of the warnings for all the departments are summarized in table C. Examination of these results shows that the percentage of actual hazardous events correctly announced by regional warnings is 94%. Only 6% of events having significant consequences were not announced. Nevertheless the percentage of false alarms reaches 33%, which is a relatively high value. From the Météo-France's point of view, 81% of the warnings were justified when comparing observed values of the meteorological parameters with the prescribed thresholds. From the point of view of the Civil Defence, based on the number of emergency actions, this percentage is only 55%. This result indicate that forecacasters have a tendency to overestimate the intensity of the potentially dangerous phenomena. Another result concerns the late warnings : about 42% of the warnings are issued less than three hours before the beginning of the significant event, which is a very short time period for the emergency services.

Table C : Global efficiency of the warnings issued by Météo-France toward Civil Defense

Warning Verification	Year 1995	Year 1995	Year 1996	3-Year Mean
Number of national warnings	7	9	8	**24**
Number of regional warnings	99	134%	181	**414**
Number of correct alarm rate	93%	96%	94%	**94%**
Alarm absence rate	7%	4%	6%	**6%**
False alarm rate	36%	36%	30%	**33%**
Llate warning rate	50%	40%	40%	**42%**
Pertinency (Météo-France)	80%	82%	81%	**81%**
Pertinency (Civil Defense)	70%	54%	48%	**55%**

Striking result is the difference between the global estimation of the pertninency of the warnings by Metéo-France and Civil Defense respectively. Two reasons can explain this fact : the first one is the tendency of the forecaster to overestimate the intensity of the phenomenon in order to avoid to miss a dangerous event ; the second one, is that consequences of dangerous meteorological events can be minimized when emergency services are correctly notified for implementing efficient safety measures.

This rapid evaluation of the general performances of the forecasts issued for severe weather events indicates that the exercise is rather difficult. Generally, the analysis of the synoptical situation and the guidance provided by the numerical models allows to define the area which could be affected by several dangerous meteorological phenomena. Nevertheless it remains difficult to forecast with accuracy both location and maximum intensity of mesoscale convective events. That is the reason why such phenomena have to be closely tracked by using the various nowcasting tools like dense surface networks and radar or satellite images. It is clear that the improvement of the performances of forecast offices for issuing warnings in case of severe weather depends on the quality of mesoscale numerical models. But enhancement of coordinated teledetection network and availability of new nowcasting tools still remains indispensable in order to issue warnings in due time in case of meteorological phenomena with rapid development.

TRAJECTORY FORECASTS FOR BALLOONING
EXPERIENCE FROM GAS BALLOON COMPETITIONS

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ABSTRACT

The Central Institute for Meteorology and Geodynamics ZAMG supplies hot-air and gas balloonists with trajectory forecasts. In the course of several ballooning competitions experience could be gained concerning organisatorial aspects of the advisory service as well as the information quality itself. Gas balloon data were collected during some long-distance flights and used to validate the trajectory calculations. Trajectory ensembles give information about the reliability of the trajectory forecast.

INTRODUCTION

Trajectory forecasts provide balloonists with valuable information for flight-planning. In the case of long-distance gas balloon flights, ZAMG offers isobaric trajectory forecasts based on ECMWF-windfields. If the flight lasts for more than one day, updates are given using the actual balloon position as starting point for the trajectories. The actual balloon position is received from the crew, that chases the balloon by car. The trajectory update and additional information (e.g. probability of rain) is given to the crew via telephone or fax.

ECMWF-windfields are too coarse to resolve flow structures in Alpine valleys. Thus, for regional hot-air balloon flights, trajectories based on higher-resolution windforecasts are needed (Baumann et al., 1996). ZAMG is going to test the validity of the windfield forecasts of the limited area model ALADIN for this purpose.

THE MODEL

The trajectory model is part of the emergency response model system TAMOS (Model System including the Semi-Automatic Meteorological Network TAWES). The trajectory model calculates different kinds of vertical displacement, including three-dimensional, constant model-level, isentropic trajectories. Isobaric trajectories can be interpreted as tracks on different flight levels and are therefore regarded as the apropriate trajectory type for ballooning. The trajectory model is started using a graphical user interface. This interface provides a list of coordinates of locations and informs about the available meteorological ECMWF and ALADIN forecast data. Model results can be looked at directly by the visualization sytem MAVIS (Magics Visualization). This software package also gives easy access to ECMWF and ALADIN forecast charts, satellite images and on-line monitoring view of the data from the meteorological network. It enables the user to overlay the TAMOS model output (trajectories, concentration fields) to all the other graphical information. Thus, the meteorologist gains a good overview on the expected weather situation along the trajectories. The trajectory plot can be zoomed on screen according to the section of interest. A black-and-white picture of this plot is sent as fax.

THE PRODUCT

The trajectory plot (Figure 1) shows the trajectories on pressure levels up to the maximum flight-level (about 500 hPa) and geographical informations, as borders and main cities. In addition to the graphical information a list of coordinates, giving the trajectory positions in hourly steps, is provided in order to support the communication between the crew and the pilot during the flight. For balloonists, the pressure levels are labeld in feet, the common units for flight levels. A verbal information about the reliability of the forecast may be added as well.

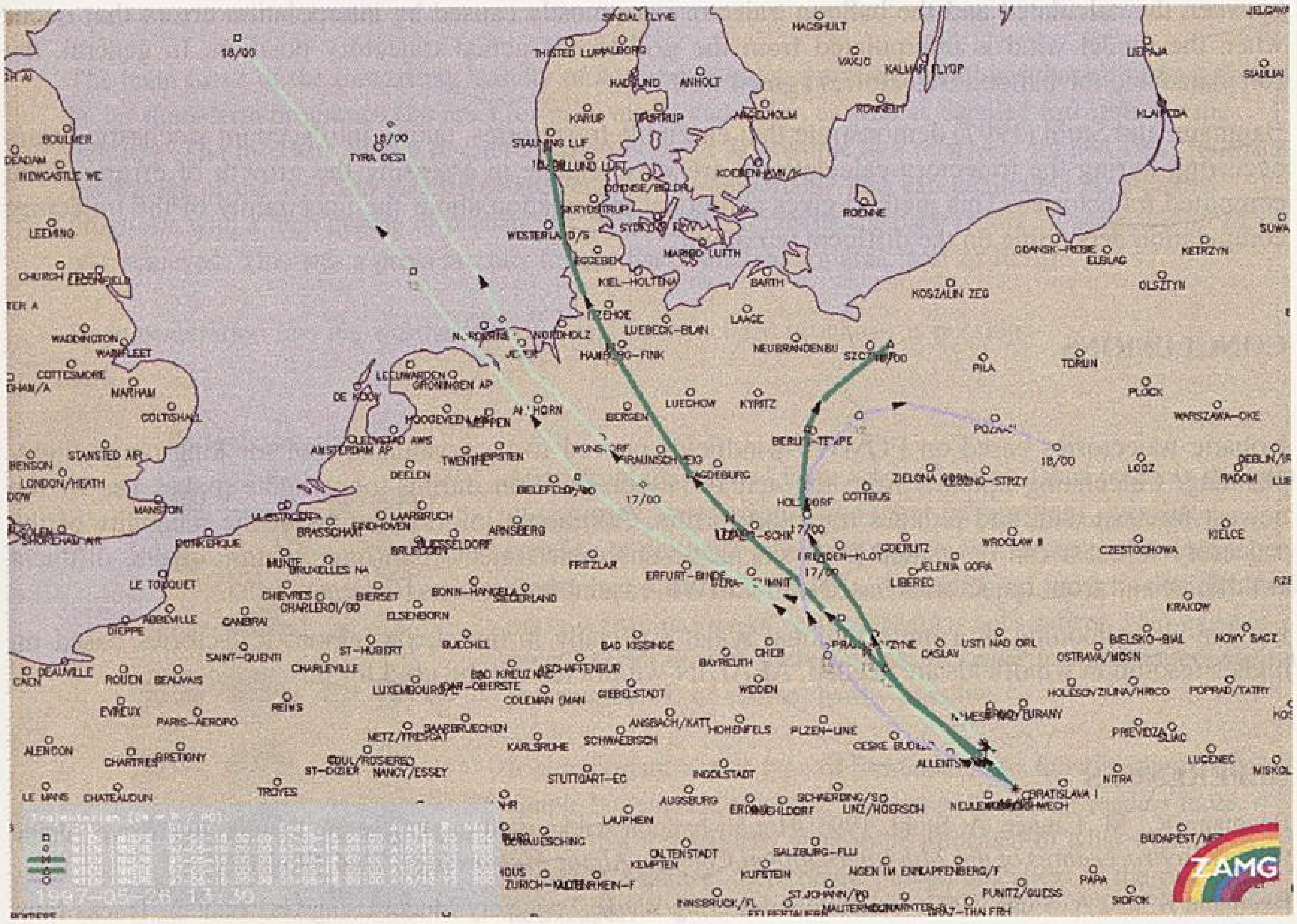

Figure 1: Forecast trajectories in 900, 800, 700, 600 and 500 hPa, starting in Vienna, 16 May, 1997 00UTC +48 hours. Trajectory positions are marked every 12 hours.

VALIDATION OF TRAJECTORY FORECASTS

Different error sources contribute to the total error of a trajectory. Truncation errors can be kept low using sufficiently small time steps. The effect of forecast errors is usually examined comparing forecasted and analyzed trajectories. Differences between trajectories based on windfield forecasts and analyses vary from case to case according to the quality of the meteorological forecast. In real-time applications, trajectories based on ECMWF ensemble forecasts could be used as a measure of reliability of the trajectory forecast.

Even with a perfect windforecast, the interpolation from a regular model grid to the actual trajectory position in space and time causes interpolation errors. Comparing computed trajectories to balloon tracks gives a possibility to assess these errors. Hourly position and height information (GPS data and manual position recording, air pressure readings) from 9 gas balloon flights during the Gordon Bennett Coups 1995 (starting from Wil, Switzerland) and 1996 (Warstein, Germany) were collected. The balloons flew for up to 91 hours. The balloon tracks were recalculated with the trajectory model based on analyzed ECMWF-windfields. The trajectory heights were adjusted to the actual balloon height at every time-step. The trajectory comparisons showed a mean distance of 15-20% of the trajectory length between the trajectory position and the balloon after the first 10-15 hours. This mean relative deviation of horizontal transport remains more or less constant for the rest of the travel time. These differences between the calculated and the balloon trajectory are mostly caused by interpolation errors that occur when the model wind is interpolated from the grid to the actual trajectory position. In general, the calculated and the balloon trajectories agreed well.

Baumann and Stohl (1997) demonstrate that ensemble trajectories, taking into account stochastic errors occurring during the trajectory calculations, are very reliable in assessing the growth of errors of the computed trajectories. This method gives additional information about the uncertainty of the trajectory computation depending on the diffluent windfield.

CONCLUSIONS

Isobaric trajectories based on ECMWF-windfields proved to be a valuable tool for long-range flight-planning. Calculating updates from the actual balloon position during long flights makes use of the newest forecast data and reduces trajectory errors. Additional information about the reliability of the trajectory forecast can be gained from stochastic ensemble trajectories (interpolation errors, diffluent windfield) and from trajectories based on ECMWF-ensemble forecasts (forecast error).

For hot-air-ballooning in a more regional scale, especially in the alpine region, trajectories based on higher-resolution windfields are needed. ALADIN-windfields will be used for this application.

REFERENCES

Baumann K., M. Langer, A. Stohl, 1996: Hot-air-balloon tracks used to analyse air flow in and above Alpine valleys. in *Proceedings of the 24th International Conf. on Alpine Meteorology*, Bled, Slovenia.

Baumann K. and A. Stohl, 1997: Validation of a Long-Range Trajectory Model Using Gas Balloon Tracks from the Gordon Bennett Cup 95. *Journ. of Appl. Meteor.*, Vol.**36**, No.6, pp 711-720.

FORECASTING ACTIVITIES OF A PRIVATE WEATHER SUPPLIER

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ABSTRACT

The main focus of the forecasting activity of a private weather provider (small weather company) should be on short-term prognoses (24 hrs.) for print media and radio, as well as detailed forecasts for the industry. The forecasts should restrict themselves as far as possible to a relatively limited area. Intimate knowledge of the area and extensive experience is also important. This can facilitate a high-quality prognosis with a high degree of probability. In 250 point forecasts for print media an accuracy of 92% was achieved. This was a press product for the East Brandenburg area, east of Berlin.

Deep penetration into the weather situation and its associated prognosis is possible.

Today's weather:

Apart from the general form a print forecast takes (such as the map of Germany, regional map and other information), it is also possible to present a particular course of weather to the newspaper reader (see picture on the left). An additional factor is that the local press is read mostly by resident regular subscribers, who express great interest in such presentations. In larger national papers such a presentation is, of course, hardly possible.

It is important in this type of presentation to show many details in simple but concise symbols, opinion polls among readers have shown that the majority want to be informed of what weather to expect at a glance, there being enough other text in the rest of the newspaper.

Even a small weather company should be technically on top in order to be able to work economically, and, of course, fast data transmission is especially important.

The policy on prices has to follow that of the DWD, even when it is possible to pass the data on at a cheaper rate (which is, no doubt, possible with smaller companies).

Smaller weather companies that are not too far apart territorially should cooperate, especially with regard to mutual replaceability (vacation, illness), consultation on the prognosis and the exchange of certain data.

Cooperation should also take place with the DWD, not only with regard to the basic data, but also to reach agreement concerning the exact serving of customers.

CLOUD COVER FORECASTING IN VIEW OF OPTIMIZING THE PROGRAMMING OF SPOT

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ABSTRACT

The SPOT satellite Earth Observation System was designed by the CNES (French Space Agency) to provide high resolution visible images of the Earth. It is operated by SPOT Image.
It is constituted of a sun-synchronous and phased satellites family (at present SPOT 1, 2 and 3. SPOT 4 is planed for launching in 1998), of ground reception stations spread around the world and of an Acquisition Programming Center located in the Spot Image head office building in Toulouse.
Each day, the Acquisition Programming Center transmits a payload work plan for the next 24 hours to each operational satellite.

The acquired scenes have a commercial interest but when the cloud cover does not overpass a ratio tolerated by the customers. Usually, there are three kinds of contracts : the users may accepts scenes with 0%, less than 10% or less than 25% cloudiness.

Before april 95, weather conditions were not considered for acquisition programming, leading to a big wastage because of the too important cloud cover recorded on the scenes. About 85 percents of the scenes were useless.
The design of a New Acquisition Programming Center was an opportunity for the CNES to consider the interest of weather forecasts in SPOT programming.

A first study has consisted in a direct comparison between the cloud cover observed by the meteorological stations and the cloud cover computed predicted field. The bad prediction ratio was too important for the final use by Spot Image despite a pretty good global result.

Furthermore, there are others techniques of numerical prediction based on the use of model output fields and statistical methods. Such methods have given goods results in several cases for meteorological predictions.

Following studies led to a customized data providing.

The predictions are focused on the low cloud amount and are independently calculated for 0%, less than 10% and less than 25% cloud cover classes. For each class, the probability to have such a cloud cover is calculated.
The predictions are generated on all earth land surfaces with a mesh size of 166 kilometers.
The predictions are computed for the 24-hour period following the payload work plan transmission. On each mesh, the probabilities are computed for the satellite pass over time.

The forecast method is based on the Multiple Discriminant Analysis (MDA) and Perfect Prognosis Method.The predictors are the prognostic variables of the operational numerical weather model and some derivatives values such as potential temperature, vorticity, etc. This allows to integrate non-linear mecanisms which would not be implicitly taken into account by MDA linear methods.
The predicted variable is the cloud cover observed from the meteorological stations. These stations are clustered in homogeneous groups by a Hierarchical Classification method in order to simplify the operations and give large populations for statistical calculus.
Once the predictors have been chosen and the discrimination functions have been estimated, the probability functions are derived from the frequency distributions.

The new Spot Image Acquisition Programming Center is on duty since april 1995. After one year of operational use, the overall acquisition success rate has risen for 15 percents up to 35 percents.
The results are not homogeneous all around the world. Studies have been undertaken on the operational results in order to identify the weakness of the predictions and to remedy then.

APPLICATIONS OF METEOROLOGICAL ANALYSES AND DATA IN THE INSURANCE INDUSTRY

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ABSTRACT

The drastic increase in the claims burden to insurance from natural catastrophes over the past two decades has induced a sharp increase in the demand for meteorological risk assessment and decision-making aids for the insurance industry, which has always been an important client of the weather services.

As a rule, it is the rare and especially the damage-laden extreme events that worry insurers due to their apparent unpredictability and their potential for becoming aggravated (in intensity and frequency) in the wake of expected anthropogenic climatic change. Here numerous meteorological parameters are of significance for the insurance industry and its various exposed classes of business (see table).

The insurance industry requires comprehensive meteorological support and assistance in a broad range of aspects, starting with up-to-date storm, windstorm and flood warnings that serve as a basis for implementing well-directed loss mitigation measures, through to the analysis of extreme individual events within the context of evaluations of causes of loss and loss adjustment, and even including simulation of catastrophe scenarios of different occurrence probabilities and of possible effects of climatic change. The insurance industry has traditionally obtained this data from weather services, but is now increasingly also using the services of specialized consultancy firms.

In addition to this, more and more insurers with global operations, reinsurers in particular, are establishing their own geoscientific advisory groups, which, on the one hand, meet the company's own needs, but, at the same time, make available to their clients special service products for assessment of a company's natural hazard exposure. These frequently constitute a basis for making far-reaching decisions on business policy.

Conversely, the insurance industry has at its disposal numerous instruments for motivating the public and also economic and political decision-makers to promote loss reduction measures and these instruments are increasingly used to emphasize the necessity for speedy and far-reaching disaster prevention and climate protection policies.

References

. Greenhouse Earth - More Extremes. Topics 1/97, pp. 13-15, Munich Reinsurance 1997.
. Flooding and Insurance. 56 p., Munich Reinsurance 1997.
. Windstorm - New Loss Dimensions of a Natural Hazard. 116 p., Munich Reinsurance 1990.

Meteorological Extremes and Their Effects on Insurance

Meteorological parameter	*Relevant extremes*	*Effect*	*Highly exposed insurance branches*
Temperature	absolute/daily maximum	heat wave	health, life, commercial
	monthly/seasonal maximum	heat wave, drought, pest, disease	health, life, agricultural
	daily/monthly minimum	frost, icing	health, agricultural, homeowner, motor own damage
Precipitation	hourly/daily maximum	flash flood	homeowner, commercial, motor o.d.
	weekly/monthly maximum	flood, inundation	homeowner, commercial, agricultural, marine
	monthly/seasonal minimum	drought, subsidence	agricultural, homeowner
Wind speed	absolute/hourly maximum, frequency	windstorm (severe storm, tornado, tropical cyclone, winter storm), storm surge	homeowner, commercial, motor o.d., aviation, marine
Hail, lightning	frequency, severity	impact	homeowner, commercial, motor o.d., aviation, marine

ASSESSMENT OF EUROPEAN WINTERSTORM HAZARD

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ABSTRACT

Historical records of insured losses caused by natural catastrophes reveal an increase with respect to both the amount and the frequency of event losses during recent years. The list of events includes for example the 'great' storm of October 1987 and the series of storms during the early months of 1990. This extraordinarily stormy period left deep traces in the accounts of insurers and reinsurers and fuelled questions about the (prospective) frequency and intensity of such events. Here a method is presented to explore the history of major European winterstorms. The approach incorporates a simple physio-mathematical model to calculate sustained near-surface winds as the first component and empirically derived gust factors to estimate gust speeds as the second component. Using this method more than 120 major storms affecting western Europe after 1896 have been reconstructed; by reason of data availability most of these storms date to the period after 1946. The method's ability to reconstruct quasi-realistic wind patterns is shown by comparing an observed and a modelled wind field. Focusing on the time frame 1946 - 1994 we show the occurrence pattern of major winterstorms together with a measure for their intensity.

The dynamical framework adopted to reconstruct historic events refers to a 2-dimensional inviscid adiabatic incompressible flow on a f-plane. The corresponding dimensionless momentum equations can be written as:

$$u' = -p'_{y'} - R_o D' p'_{x'} - R_o^2 D'^2 u'$$
$$v' = p'_{x'} - R_o D' p'_{y'} - R_o^2 D'^2 v'.$$

Dashed terms denote dimensionless variables, subscripts define partial derivatives and *(u, v), (x, y), t, p, D* are in turn the horizontal velocity and distance components, time, atmospheric pressure and the total derivative $(D = \partial/\partial t + u\partial/\partial x + v\partial/\partial y)$ along a fluid parcel's trajectory. The first terms on the right hand side represent the geostrophic wind components and the following terms - scaled by the Rossby number ($R_o = U/fL$) - define the ageostrophic flow components. Here U is the unperturbed mean flow, f is the Coriolis parameter and L is the typical length scale of the atmospheric phenomenon under consideration. To elucidate the importance of the various terms, weather patterns with different length scales can be considered. Thereby it becomes evident, that for a rough representation of the circulation patterns associated to mid-latitude frontal structures ($U = 10\ ms^{-1}$; $f = 10^{-4}\ s^{-1}$; $L_{across\_front} \sim 200\ km$; $R_o \sim 0.5$) terms of the order of R_o have to be taken into account. Neglecting all R_o^2-terms and reformulating, results in a diagnostic set

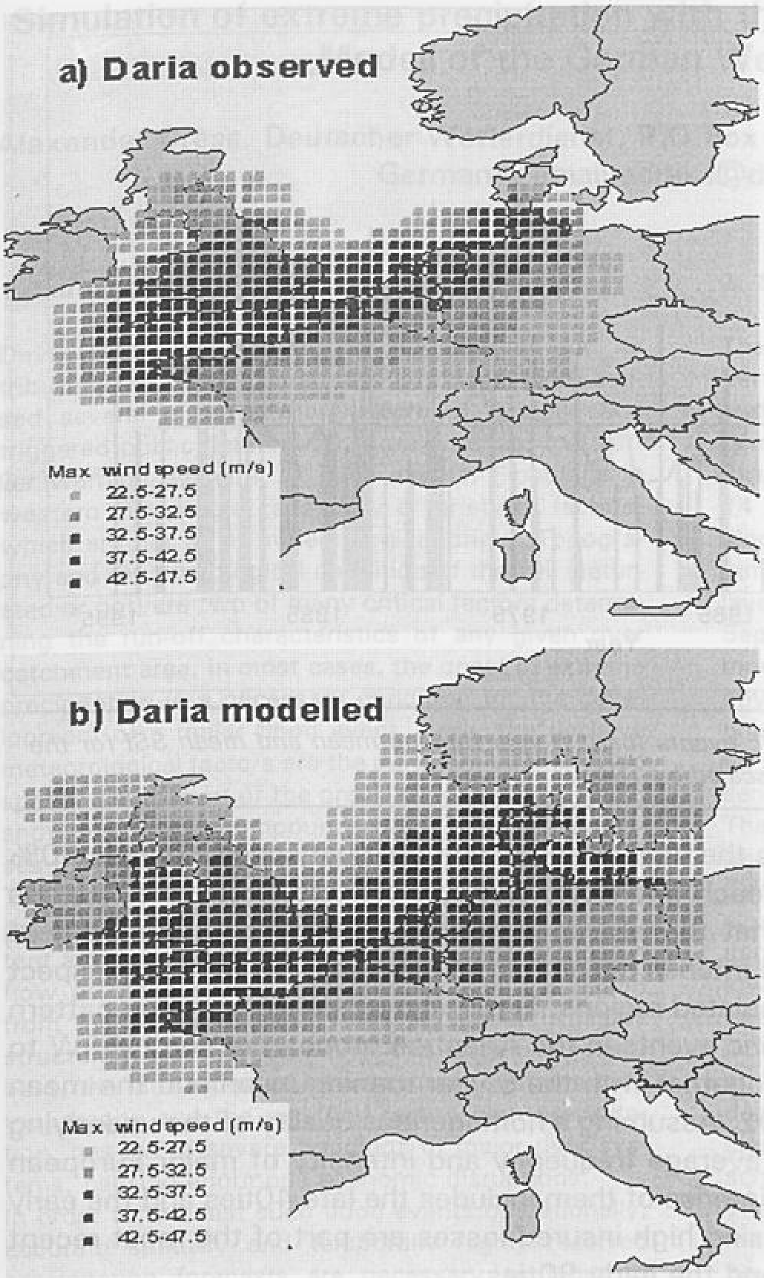

Fig. 1: Panel a): observed gusts from the British, French, Belgian, Dutch, German and Danish weather services. Panel b): modelled gust field.

of equations for the horizontal velocity components. Its various terms depend only upon higher order partial derivatives of pressure patterns and are therefore well suited to reconstruct sustained winds of historic storms based on easily accessible Sea Level Pressure (SLP) data.

To adequately model the gustfield of a storm a distinction is made between the vertical momentum flux in the vicinity and far away from frontal structures. In the former case convective processes are most important whereas in the latter case the vertical momentum flux is dominated by frictional effects at the earth's surface. Therefore frontal and non-frontal gust factors are distinguished and derived using empirical data.

Within this dynamical framework flow patterns with typical length scales of about 100 km or larger can be adequately captured. Keeping this limitation in mind and comparing the position, structure and intensity between the observed (Fig. 1a) and the modelled (Fig.1b) storm field of 'Daria' (25 January 1990), a good agreement is found. Note that the differences between the two storm fields in Ireland, southern Scandinavia, eastern Germany, Poland, the Czech Republic and the northeastern parts of the Atlantic are due to the lack of observed data.

About half of the events of the storm catalogue have been selected during a two-stage selection process. Its first criterion relates to physical properties of the SLP and wind fields. Its second criterion refers to the ranking of a loss index that is calculated using stormfields with a rough representation of frontal and non-frontal gusts and either uniformly or demographically distributed values in the Atlantic-European region. The other events in the storm catalogue have been reported in the literature or stem from sources within the insurance industry.

The Storm Severity Index ($SSI = V^3DA$) is used as a measure for the intensity of a storm and to identify periods of increased storm activity. Here V and D are the maximum gust

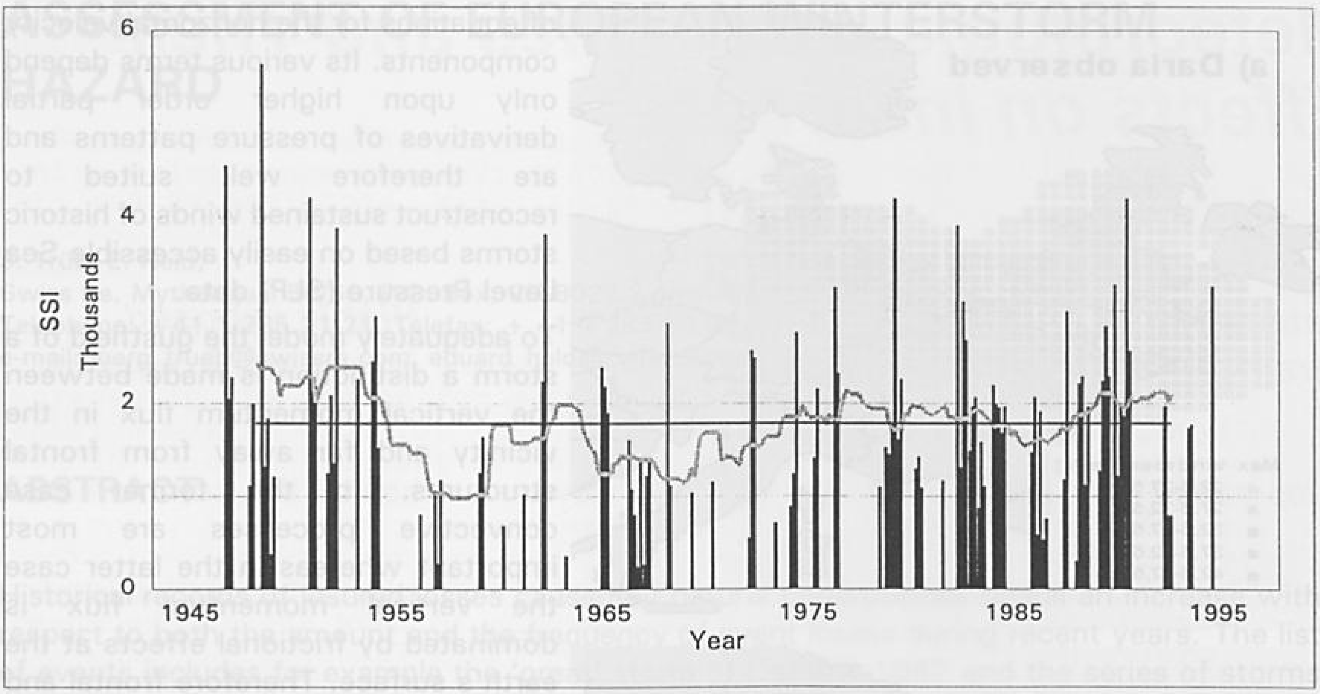

Fig.2: Storm Severity Index (SSI) for historic events (bar), 5 year running mean and mean SSI for the period 1948-1992 (horizontal line); all SSIs scaled by 10^9.

speed and storm duration (calculated as the time during which the gust speed exceeds 80% of the local maximum gust speed) at each grid point and *A* is the area with gust speeds larger than 22.5 ms^{-1}. Please note, that the SSI does not correlate with the amount of insured event losses; some of the more intense events of the storm catalogue (with respect to their SSI) affected only sparsely populated regions. Fig. 2 shows the occurrence pattern and the SSI for the reconstructed historic events in the Atlantic-European region (15°W to 15° E and 35° to 60° N) after 1946 together with the 5 year running mean and the mean SSI averaged over the period 1948-1992. Assuming a homogenous quality of the underlying data, several episodes with an above average frequency and intensity of major European winterstorms are registered. The most intense of them includes the late 40ties and the early 50ties. The forementioned events causing high insured losses are part of the most recent episode that includes the late 80ties and the early 90ties.

Simulation of extreme precipitation with the high-resolution Deutschland-Modell of the German Weather Service

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1. Introduction

Devastating floodings of the Rhine River and its tributaries in 1993 (Christmas Flood) and 1995 caused several million dollars worth of damage and triggered public demand for more accurate and earlier warning systems of such events. Floodings in western Europe are caused by a variety of factors, which are not all of meteorological origin. Topography and the hydrological condition of the soil (saturated or not) are two of many critical factors determining the run-off characteristics of any given river catchment area. In most cases, the onset of extreme precipitation is a necessary condition for the development of a major flood event. Here, the decisive meteorological factors are the duration, intensity and spatial distribution of the precipitation events. Rapid snow-melt, often compounded with rain, also increases the amount of water available for discharge.
Typically, major floods in Germany occur when a prolonged period of wet weather is caused by persistent atmospheric circulation patterns that produce a flow of moisture-laden air masses over the region from the southwest and west. Especially in highly structured areas of Germany, like Baden-Württemberg, the interaction of intense storm systems with topography and the resulting record high precipitation, has led to severe floodings of major river systems, causing enormous economic disruptions.
In order to forecast such flood events operationally, accurate spatially and temporally highly resolved precipitation forecasts are necessary as input to hydrological models to improve the river run-off calculations and to increase the warning time for floodings.

Therefore, cooperation between the German Weather Service (DWD) and the Enviromental Protection Agency of Baden-Württemberg (Landesanstalt für Umweltschutz; LfU) has been established to integrate precipitation forecasts of the operational highly-resolved Deutschland-Modell (DM; $\Delta \sim 14$ km) of the DWD into the agency's river run-off model activities. The aims are to verify the ability of the numerical weather forecast model to simulate the spatial and temporal precipitation distribution during such flood events, to improve the understanding of orographically influenced precipitation involving frontal precipitation, mountain waves and blocking effects, and to improve the results of the river run-off models, including precipitation forecasts.

2. The model

The Deutschland-Modell of the German Weather Service is a hydrostatic high-resolution meso-ß-scale numerical weather prediction model (NWP) currently used as the DWD's main short-range forecast model. It has a horizontal resolution of 14 km and covers Germany and some surrounding areas. The vertical structure of the model's atmosphere is currently resolved into 20 vertical layers; a 30-layer version will be operational by Sep. 1997. A comprehensive description of the model is found in Majewski (1991, 1995). The physical processes parameterized includes a sophisticated soil model with two layers in the soil for the heat and water budgets as well as a representation of snow (Jacobsen and Heise, 1982). The precipitation parameterization is divided into grid-scale and convective rain and snow modules. Grid scale rain and snow are determined from cloud water content using a Kessler-type cloud microphysics parameterization in which the following processes are considered: interaction between water vapour, cloud water, rain and ice, including autoconversion of cloud water to rain and ice, accretion, riming, shedding, melting, deposition and evaporation of rain and ice particles. Moist convection is given by a mass flux scheme after Tiedtke (1989).
The initial conditions are provided by a 6-h intermittent assimilation scheme on the DM grid. As boundary values, the output of the DWD's Europa-Model (EM; $\Delta \sim 55$ km), the main forecast model for the synoptic meso-α-scale is used every hour.

3. Model results

So far, five different periods of major flood events have been simulated by the DM. For brevity's sake only one representative example for a period of extreme precipitation, the "Christmas Flood" in Dec. 93, will be presented.

The simulated flood period from 16 - 25 December 1993 was characterized by a strong and persistent westerly atmospheric circulation in which a series of low pressure systems and their attendant frontal zones impacted western and central Europe and led to intense, long-lasting precipitation. During Dec. 20-12, 1996 precipita-

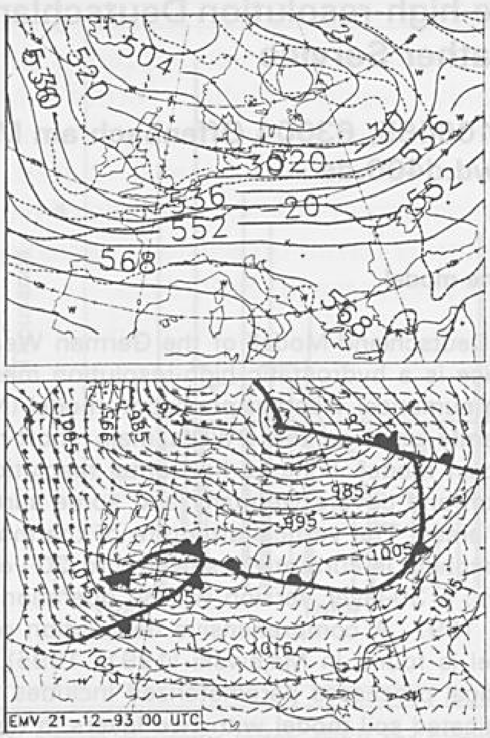


Figure 1: EM analyses of the 500 hPa geopotential height (gpdm;solid) and temperature (°C;dashed) [1a], sea level pressure (hPa) and wind directions [1b] at 21 Dec., 1993 00 UTC.

tion amounts of more than 40 l/m² were measured on many rain gauges in western and southwestern Germany (Freudenstadt/northern Black Forest 96 l/m²).

As Fig. 1 depicts, the synoptic situation during Dec. 20-21, 1996 shows a major upper-air low pressure system over northern Europe and a surface low located over the English Channel. The attendant warm front was oriented from west to east over Germany and moved slowly northeast. The strong southwesterly flow behind the warm front led warm and humid air northward against the colder air ahead of the front. The result was a strong uplifting zone accompanied by heavy cloud systems and intense, long-lasting precipitation.

In general, the observed synoptic circulation was rather closely simulated by the DM and the driving EM. Due to the higher horizontal resolution of the DM, differences to the coarser EM arise from the influence of the newly resolved sub-synoptic and mesoscale circulation features, particularly those that are related to orographic forcing. As Fig. 2 illustrates, the DM is able to realistically forecast the warm air advection and the orientation of the warm front of the low pressure system, which is an important factor in case of a sudden snow melt event due to advection of warm air by southwesterly winds. Visible over northern Germnay is a strong humidity gradient, which seperated dry, colder air over north-

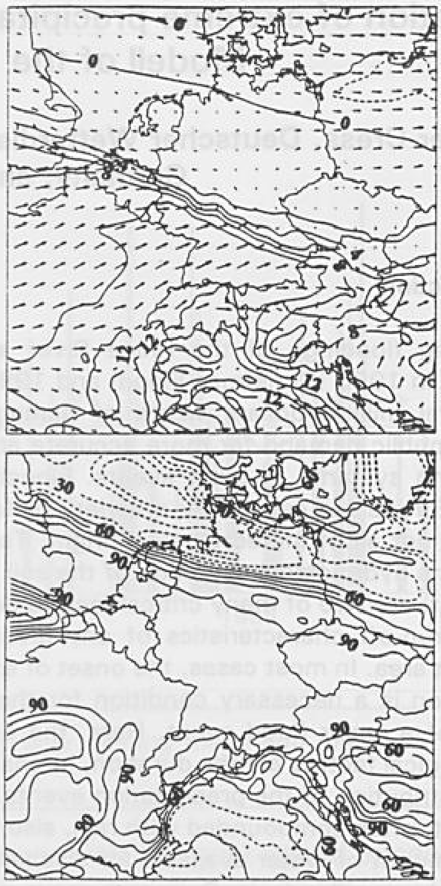


Fig. 2 18-h simulated temperature (°C), wind direction and velocity (scaled wind arrow at 20 m/s) in 950 hPa [2a] and relative humitity (%) in 850 hPa [2b] for 20 Dec., 1993 at 18 UTC.

eastern Europe from the warm and humid Atlantic air over middle and southern Germany. This is in good correspondence with satellite pictures and observations (not shown).

The simulation of realistic precipitation amounts has proven to be an extremly difficult task for modern NWP-models. This is partly due to the fact that the horizontal resolution of the models used is too coarse to capture the wide range of local-scaled rain-producing systems and that the physical and dynamic processes forcing the formation of precipitation is not understood in all its details. Especially, the forecast of extreme precipitation events caused by the interaction of large-scale forcing, topographic forcing and internal mesoscale instability is still a field of ongoing research.

In this study, we examine the precipitation forecasts of the DM during extreme precipitation events and validate it against observational precipitation distributions. The observation data used for the validation of the simulated precipitation fields were obtained from a dense network of some 4300 stations over Germany for a 24-h period and in high temporal resolution with hourly reports from about 45 stations in southwestern

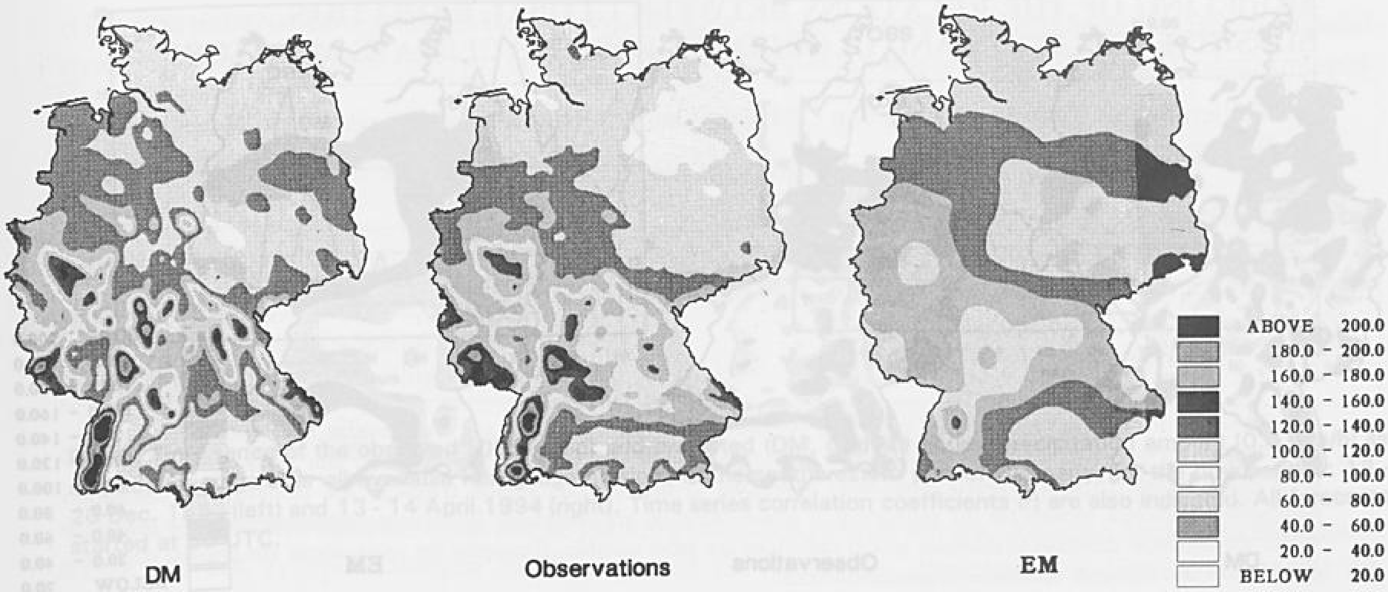


Fig 3: Simulated and observed 24-h precipitation sum [mm] accumulated from 16 - 25 Dec., 1993.

Germany (Baden-Württemberg; about 250 km x 250 km).

Fig. 3 compares the simulated (EM and DM) and observed 24-h accumulated precipitation distributions over Germany for 16-25 Dec. 1993. Obviously, because of its high horizontal resolution, the DM is able to predict quite realistically, the observed precipitation distribution, with maxima over the mountain tops and minima in the river valleys. Most of the precipitation is generated in the upslope motion on the upwind side of the mountain ranges, with a sharp decrease on the lee side. In comparison to the observations, the model tends to overestimate the precipitation on the upwind side and underestimate the precipitation on the lee side of the mountains. One reason could be an insufficient treatment of the hydrostatic mountain wave in the model. This is being addressed in some sensitivity experiments. In contrast to that, the EM is to coarse to reproduce all the small-scale details of the observed precipitation distribution during such extreme flood events.

To evaluate the 24-h accumulated precipitation forecast of both models quantitatively, the true skill statistics (TSS) score is computed, using all relevant information about the observations and forecasts. It ranges from -1 to +1. Perfect forecasts receive a score of one, random forecasts receive a score of zero, and forecasts inferior to the random forecasts receive negative scores. Thereby, the precipitation values at the four DM grid points surrounding each observational point were bilinearly interpolated onto the observation site.

As Fig. 4 depicts, the DM has a much higher skill to forecast extreme precipitation events than the EM, whereas for low and medium precipitation rates both models are comparable. One reason could be, that precipitation is difficult to forecast at the right place and time, and any forecast system that smoothes or avoids variability also escapes from the heavy skill score penalties which follow every time these features were wrongly forecast.

Another important aspect of an effective flood forecast is the ability of the numerical weather prediction model to simulate the temporal precipitation course accurately. Therefore, Fig 5 outlines the observed and simulated precipitation time series for two different flood periods. Apparntly, the correlation between the observed and simulated

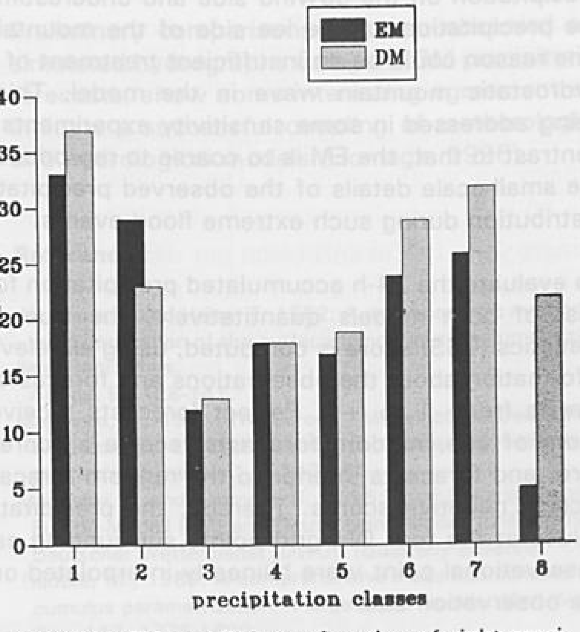
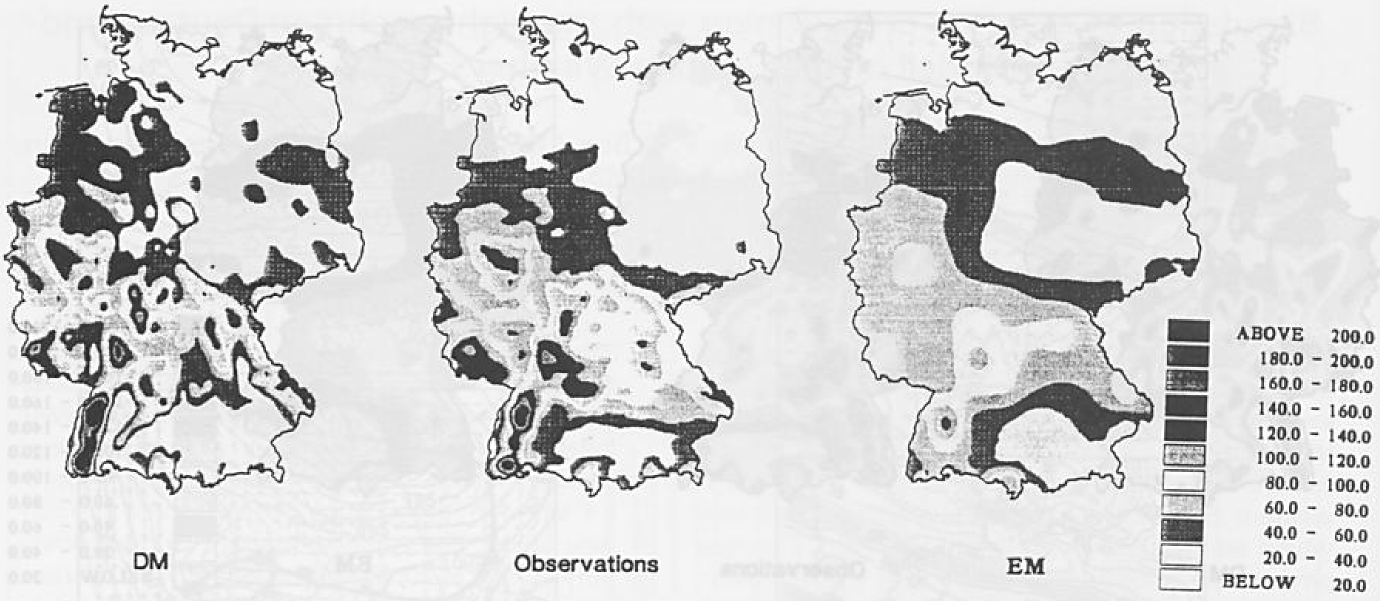


Fig 4: TSS for EM and DM as a function of eight precipitation classes for all five simulated flood periods. (Classes: 1: <0.1 mm; 2: 0.1 mm - 1 mm; 3: 1 mm - 2 mm; 4: 2 mm - 5 mm; 5: 5 mm - 10 mm; 6: 10 mm - 25 mm; 7: 25 mm - 50 mm; 8: >50 mm / 24h)



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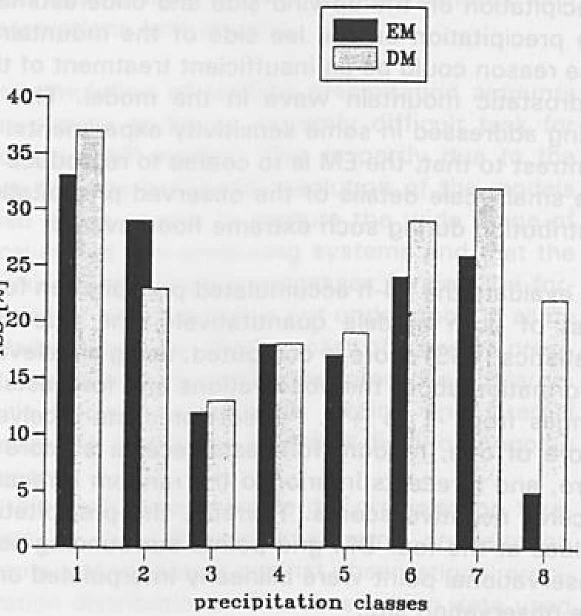

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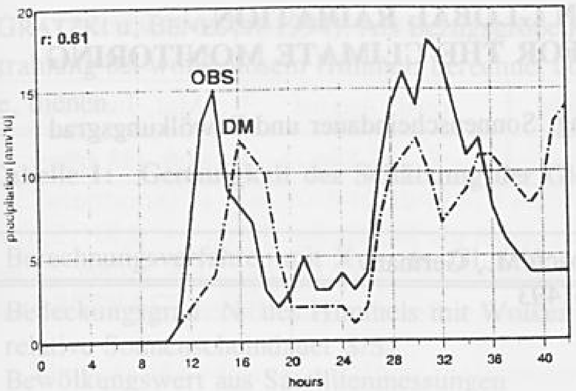

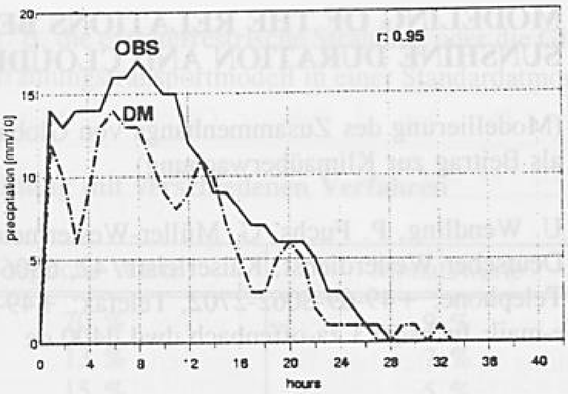

Fig. 5: Time series of the observed (OBS; solid) and predicted (DM, dashed) hourly precipitation amount [0.1 mm/h] as a spatial average over all available rain gauge stations in the southwestern part of Germany, for the time periods: 19 - 20 Dec. 1993 (left) and 13 - 14 April 1994 (right). Time series correlation coefficients (r) are also indicated. All forecasts started at 00 UTC.

time series are quite high. Especially the beginning and end of individual intense rain events, which are important factors for a realistic flood forecast, are successfully simulated. Due to the fact that even a high-resolution NWP model like the DM is too coarse to capture all the small-scale variability, corresponding precipitation simulation at single stations (not shown) is still not satisfactory.

4. Summary

A successful on-line flood forecast system needs accurate (spatial and temporal) precipitation and temperature forecasts as input to hydrological models to improve the forecast skill for critical run-off situations and to increase the warning time of flood events. This paper presents results of the DWD's operational regional weather prediction model (DM) simulation of one out of five periods of long-lasting continuous heavy precipitation events, leading to severe floodings in major German river systems.

The study's principal objective was to evaluate the potential usefulness of regional weather forecast models to simulate severe precipitation events, to reproduce the temporal precipitation course of such flood events and to improve the understanding of orographically induced precipitation events. Additionally, the DM precipitation forecasts will be used by the LfU and other hydrological agencies to improve the quality of their river run-off models.

The general the DM and the driving EM were able to successfully reproduce the general synoptic circulation leading to the observed heavy precipitation events.

The simulated (DM) and observed precipitation distributation, with maxima over the mountain tops and minima in the river valleys, depicts a rather close correspondence. There are still some deficiencies in mountainous areas, where the DM tends to overestimate the precipitation on the windward side and underestimate the precipitation on the lee side of the mountain. A comparison with the driving EM precipitation forecasts clearly indicates that the coarser EM is not able to simulate the observed extreme precipitation distribution leading to major floodings precisely.

Besides the spatial precipitation distribution the temporal precipitation course is a decisive factor for effective flood forecasts and was simulated in close correspondence to the observations for greater watersheds. But even a high-resolution NWP model is still too coarse to capture all the observed precipitation variability, corresponding precipitation forecast for smaller catchment areas or even single stations is still not satisfactory.

Preliminary comparisons between observed and simulated hydrographs using the DM precipitation forecasts, show some interesting agreement and indicate a successful coupling of meteorological and hydrological models (Homagk, 1996).

References

Jacobsen, I. and Heise, E, 1982: A new economic method for the computation of the surface temperature in numerical mo dels. Beitr. Phys. Atmos. 55,128-141.

Majewski, D., 1991: The Europa - Modell of the Deutscher Wetterdienst. ECMWF Seminar on "Numerical methods in atmospheric models " 2, 147-191.

Majewski, D. and Schrodin, R., 1995: Short Description of the Europa-Modell (EM) and Deutschland-Modell (DM) of the Deutscher Wetterdienst (DWD). (Quarterly Bulletin).

Tiedtke, M., 1989: A comprehensive mass flux scheme for cumulus parametrization in large-scale models. Mon.Wea. Rev. 117, 1779-1800.

Homagk, P., 1996: Hochwasserwarnsystem am Beispiel Baden-Württemberg. Geowiss. 14, Heft 12, 539 - 546.

MODELING OF THE RELATIONS BETWEEN GLOBAL RADIATION, SUNSHINE DURATION AND CLOUDINESS FOR THE CLIMATE MONITORING

(Modellierung des Zusammenhangs von Globalstrahlung, Sonnenscheindauer und Bewölkungsgrad als Beitrag zur Klimaüberwachung)

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SUMMARY: For climate monitoring, especially for the computation of energy and water cycles, it is necessary to know the components of radiation and their regional and temporal variability. The network of in situ measurements ist not sufficient for that purpose. Models have been developed to improve the spatial coverage and resolution of radiation parameters. Different models for the estimation of global radiation are compared. For climatological purposes the models, which use sunshine duration to estimate global radiation, are most suitable. Examples for applications are gridded maps of global radiation and gras reference evapotranspitation.

ZUSAMMENFASSUNG: Zur Klimaüberwachung, insbesondere des Energie- und Wasserhaushalts, ist die möglichst genaue Erfassung der Strahlungskomponenten in ihrer regionalen und zeitlichen Variabilität erforderlich. Die direkte Messung erfolgt an einzelnen Punkten mit relativ großer Maschenweite des Netzes. Zur Verbesserung der Datenabdeckung nutzt man heute Satellitenmessungen und empirische Modelle. In der vorliegenden Arbeit werden zwei Modelle, die eine Bestimmung von Schätzwerten der Globalstrahlung aus dem Bedeckungsgrad mit Wolken bzw. der Sonnenscheindauer ermöglichen, näher untersucht. Auf die Bestimmung der Globalstrahlung aus Satellitendaten wird eingegangen. Als Anwendungsbeispiele werden Rasterkarten der Globalstrahlung und der Gras-Referenzverdunstung gezeigt.

Gegenwärtig wird im Strahlungsmeßnetz des DWD an 42 Stationen die Globalstrahlung sowie an einigen Stationen zusätzlich die diffuse Himmelsstrahlung und die atmosphärische Wärmestrahlung gemessen. Die ca. 120 synoptischen Stationen melden stündlich den Bedeckungsgrad des Himmels mit Wolken. Etwa 300 Stationen in Deutschland registrieren die Sonnenscheindauer, die ebenfalls stündlich ausgewertet vorliegt. Hier sind für klimatologische Bearbeitungen 30jährige, teilweise auch längere Beobachtungsreihen verfügbar. Bei ihrer Auswertung bestehen jedoch Schwierigkeiten, da vor allem an den nebenamtlichen Klimastationen die Messung teilweise durch Horizontabschirmung, d. h. zwischenzeitliche Bebauung, hochwachsende Bäume usw., beeinträchtigt ist. Durch fehlerhafte Messungen einzelner Stationen können regionale und zeitliche Änderungen vorgetäuscht werden, so daß Daten der Sonnenscheindauer bei der Verwendung in Modellen, zur Kartierung der Strahlungsbedingungen oder bei Aussagen zum Langzeitverhalten kritisch zu bewerten sind.

Für die zukünftige Nutzung der Globalstrahlung zu Beratungszwecken und zur Klimaüberwachung ist das Meßnetz zu weitmaschig. In Deutschland repräsentiert eine Meßstation im Durchschnitt eine Fläche von 80 x 80 km². In anderen europäischen Ländern dürfte die Flächendichte von Strahlungsmessungen meist weit geringer sein. In Zukunft bietet nur die Kombination von Boden- und Satellitenmessungen in Verbindung mit Modellrechnungen die Möglichkeit, für ein größeres Gebiet (Europa) eine kontinuierliche und flächendeckende Bestimmung der Globalstrahlung durchzuführen. Daher sind Fernerkundungsverfahren mittels Satelliten zur Erfassung der Strahlungsgrößen heute unverzichtbar.

Empirische Modelle zur Berechnung der Globalstrahllung gehen meist davon aus, daß zwischen der relativen Strahlungsgröße R_G/R_0 und einer einfacher meßbaren, für die Strahlung relevanten Größe X die Beziehung

$$R_G / R_0 = a + b \cdot X \tag{1}$$

besteht. Dabei kann X die relative Sonnenscheindauer S/S_0 sein (ÅNGSTRÖM 1924, HEINRICHSEN 1994) oder eine Funktion des Bedeckungsgrades N des Himmels mit Wolken (KASTEN u. a. 1984), aber auch ein aus Satellitenmessungen ermittelter Relativwert für die Bewölkung für Flächen mit ca. 8 x 8 km² Auflösung

(GRATZKI u. BENESCH 1994). Als Bezugsgröße R_0 kann z. B. die extraterrestrische Strahlung oder die Globalstrahlung bei wolkenlosem Himmel, berechnet über ein Strahlungstransportmodell in einer Standardatmosphäre, dienen.

Tabelle 1: Genauigkeit der Schätzung der Globalstrahlung mit verschiedenen Verfahren

Berechnungsverfahren mit X = (s. Gl. (1))	tägliche Werte	Monatswerte
Bedeckungsgrad N des Himmels mit Wolken	20 %	9 %
relative Sonnenscheindauer S/S_0	13 %	7 %
Bewölkungswert aus Satellitenmessungen	15 %	5 %

Das Satellitenmodell mit der größten Genauigkeit (s. Tab. 1) erfordert den höchsten Bearbeitungsaufwand und ist an den Pixeln mit Messungen der Globalstrahlung an diese anzupassen. Daher kann das Verfahren gegenwärtig noch nicht für aktuelle, zeitkritische Beratungsaufgaben genutzt werden. Angaben des Bedeckungsgrades stehen aus den Synop-Meldungen stündlich aktuell zur Verfügung, Berechnungen damit kommen für die tägliche Beratung wegen der geringeren Genauigkeit aber nur als Orientierungswerte in Frage.

Die Berechnung der Globalstrahlung aus der Sonnenscheindauer ist ein guter Kompromiß zwischen Aufwand und Genauigkeit, insbesondere für klimatologischen Untersuchungen zum Wärme- und Wasserhaushalt wie auch zur Berechnung der Verdunstung. Unterschiedliche und in den Reihen nachträglich nicht mehr korrigierte Fehler durch Horizontabschirmung bereiteten bisher Schwierigkeiten. Sie lassen sich durch eine Modifikation des Ångström-Verfahrens ausschalten. Herkömmlicherweise ist die relative Sonnenscheindauer auf die astronomisch mögliche Sonnenscheindauer S_0 zwischen Sonnenauf- und -untergang bezogen. Der Sonnenschein-Autograph kann aber bekanntlich nicht sofort mit Sonnenaufgang eine Brennspur erzeugen. Dazu ist eine gewisse Strahlungsenergie erforderlich, die auch bei wolkenlosem Himmel erst ab einem Grenzwinkel α zwischen 6 und 15° Sonnenhöhe erreicht wird, in Abhängigkeit von der Trübung der Atmosphäre. Daher beträgt die an einem wolkenlosen Tag gemessene maximale Sonnenscheindauer nur etwa 80 % der astronomisch möglichen Werte, die relative Sonnenscheindauer wird zu klein angegeben und erreicht nicht 100 %. In Tab. 2 werden der astronomisch möglichen Sonnenscheindauer S_0 (entspricht Sonnenhöhen > 0°) die maximale Registrierdauer von Sonnenschein für andere Grenzwinkel α gegenübergestellt.

Tabelle 2: Astronomisch mögliche Sonnenscheindauer S_0 für 50°N und maximal mögliche Registrierdauer des Sonnenscheins bei verschiedenen Grenzwinkeln α, jeweils für die Mitte des Monats in h:min

Grenzwinkel	Februar	April	Juni	August	Oktober	Dezember
α = 0°	10:09	13:47	16:21	14:28	10:47	8:07
α = 5°	8:49	12:35	14:52	13:09	9:28	6:29
α = 10°	7:37	11:32	13:42	12:05	8:20	4:49
α = 15°	6:18	10:30	12:35	11:03	7:08	2:22

Das modifizierte Verfahren zur Bestimmung der Globalstrahlung setzt in Gl. (1) für die Größe X nicht S/S_0 ein, sondern den in allen vollen Stunden mit Sonnenhöhen > 15° registrierten Zeitanteil mit Sonnenschein (S_r in %). In Modellen zur Berechnung der Globalstrahlung reicht der Bereich mit Sonnenhöhen > 15° aus, da der überwiegende Teil der Strahlungsenergie im Tagesgang (in den Monaten April bis Juli 95 % und im Winter noch über 75 %) erfaßt wird. Die Abgrenzung von Auswertbereichen (s. Tab. 3) macht die Modellierung wesentlich zuverlässiger, da

- die Fehler durch Horizontabschirmung weitgehend ausgeschaltet werden,
- die unsicheren Abschnitte der Brennspur morgens und abends unberücksichtigt bleiben und
- die Auswertung nur für volle Stunden erfolgt, also direkt den benötigten Relativwert angibt.

Tabelle 3: Auswertbereiche der Sonnenscheindauer S_r für ein verbessertes Ångström-Verfahren

Nov., Dez., Jan.	Februar, Oktober	März, September	April, August	Mai, Juni, Juli
10 - 14 Uhr	9 - 15 Uhr	8 - 16 Uhr	7 - 17 Uhr	6 - 18 Uhr

Die Regressionsrechnung für 88 Wetterstationen und 30 Jahre ergibt die Beziehung $S / S_0 = 0{,}81 \cdot S_r$ (mit B = 97,3 %), d. h. die relative Sonnenscheindauer bei Sonnenhöhen > 15° ist um ca. 20 % größer als der bisher angesetzte Wert, bezogen auf die Tageslänge S_0. Die verbesserte Beziehung zur Berechnung der Globalstrahlung R_G lautet dann für Tageswerte in J/cm²:

$$R_G = R_0 \cdot (0{,}20 + 0{,}46 \cdot \frac{S_r}{100}) \qquad (2)$$

Die extraterrestrische Strahlung R_0 wird wie bisher aus dem Tag des Jahres und der geographische Breite des Standortes für jeden Tag einzeln berechnet (WENDLING u.a. 1997). Die astronomisch mögliche Sonnenscheindauer ist nicht mehr erforderlich, da die direkt aus der Registrierung gewonnene Größe S_r (in %) eingeht. Nach HEINRICHSON (1994) unterscheiden sich die Koeffizienten a und b im Jahresgang und auch regional, eine Neuberechnung von Gl. (2) mit dem Daten des Strahlungsnetzes des DWD ist vorgesehen.

Anwendungsmöglichkeiten von Gl. (2) sind z. B. Monatskarten der Globalstrahlung für operationelle Beratungszwecke. Dazu sind zunächst die aktuellen Monatsmittel der Sonnenscheindauer S_r > 15° aller im DWD verfügbaren Stationen (ca. 250) nach dem von MÜLLER-WESTERMEIER (1995) entwickelten Verfahren auf das Raster von 1 x 1 km² zu interpolieren. Sodann ist rasterweise die Globalstrahlung nach obiger Gleichung zu berechnen. Als Beispiel wird im Vortrag eine Karte der Globalstrahlung für den Monat August 1995 gezeigt. Vergleicht man die Ergebnisse des Kartierungsverfahrens an den Rastern, wo gemessene Strahlungsdaten vorliegen, so ergeben sich mittlere Fehler, die unter 5 % liegen. Damit erscheint das Verfahren für die Anwendung in der Praxis geeignet. Als ein weiteres Anwendungsbeispiel wird im Vortrag eine Karte der mittleren Monatssumme der Gras-Referenzverdunstung für den Monat Juli (Mittel 1961/90) gezeigt, die auf der Basis der bekannten Penman-Monteith-Beziehung unter Verwendung der Globalstrahlung nach Gl. (2) berechnet wurde. Sie ist u. a. ein Zwischenprodukt für Karten bei der Neubearbeitung des Hydrologischen Atlas von Deutschland.

Für Zwecke einer zukünftigen Klimaüberwachung der Komponenten des Energie- und Wasserhaushalts werden in ähnlicher Form Kombinationen von gemessenen Boden- und Satellitendaten sowie von Modellergebnissen herangezogen werden müssen. Die hierfür zu entwickelnden Verfahren bilden eine Grundlage für die Satellitenklimatologie zur statistischen Auswertung von aufbereiteten Fernerkundungsdaten. Diese neue Aufgabe wird in Zukunft die traditionelle Arbeit in der Klimatologie des DWD vorteilhaft ergänzen.

Literatur

Gratzki, A. u. W. Benesch (1994): Modifications in the operational extraction of the solar irradiance at ground level from METEOSAT data. Proc. 10th METEOSAT Scientific Users' Conference, Cascais (Portugal), EUMETSAT, EUM P 15, 475-482

Heinrichsen, K. (1994): The Ångström formula with coefficients having a physical meaning. Solar Energy 52, No. 6, 491-495

Kasten, F., K. Dehne, H. D. Behr, U. Bergholter (1984): Die räumliche und zeitliche Verteilung der diffusen und direkten Sonnenstrahlung in der Bundesrepublik Deutschland. BMFT-Forschungsbericht T 84-125, 128 S.

Müller-Westermeier, G. (1995): Numerisches Verfahren zur Erstellung klimatologischer Karten. Berichte des Deutschen Wet--terdienstes 193, Offenbach/M., 18 S.

Wendling, U., P. Fuchs u. G. Müller-Westermeiner (1997): Modellierung des Zusammenhangs von Globalstrahlung, Sonnenscheindauer und Bewölkungsgrad als Beitrag zur Klimaüberwachung. Deutscher Wetterdienst, Forschung und Entwicklung, Arbeitsergebnisse Nr. 45, 29 S.

HYDROMETEOROLOGY - TASK AND OFFER OF SERVICES FOR HYDROLOGY AND WATER MANAGEMENT

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ABSTRACT

The role of hydrometeorology for water management results from the specific significance of the components precipitation and evaporation within the hydrological cycle. Precipitation and evaporation are important controlling and input parameters in water management systems, especially water budget studies. So, for example, water storage and streamflow are definitely dependent on these hydrometeorological parameters.
On the basis of an extensive data base as well as tested and user-friendly methods, procedures and models the Deutscher Wetterdienst (Business Unit Hydrometeorology) offers specific products and consultation services for the most varied of matters relating to the long-term management of the water resources, as well as the real-time forecast and controlling of water management processes. For all that the peculiarities of the parameters precipitation and evaporation in their spatial and temporal variability and in their complex connection are taken into account. The following subjects of non real-time - applications are dealt with:

- Site-related and area-related information on (extreme) precipitation depths and meltwater releases of the snow cover for various durations - and return periods (projects KOSTRA, REWANUS)
- Estimation of maximized areal precipitation (project MGN)
- Processing of point-precipitation data to blanket covering values for different time scales (maps of ground-based precipitation measurements; maps of calibrated radar-based precipitation)
- Routine method for correcting systematic errors of precipitation measurements (cf. Fig. 1)
- Estimation of site-related and areal-related evaporation for different pattern of land use including free water surfaces (areal evaporation - Model VEKOS)
- Simulation and analysis of long time series of hydrometeorological variables

The estimation of hydrometeorological budget, defined as the difference "corrected precipitation (P_{cor}) minus evaporation (ET_a ; E_w)", will be described in more detail as an example of products and applications to help hydrology solve their problems. This information is of principle importance for water resources studies especially for investigations as to soil water budget and groundwater recharge (cf. Fig. 3).

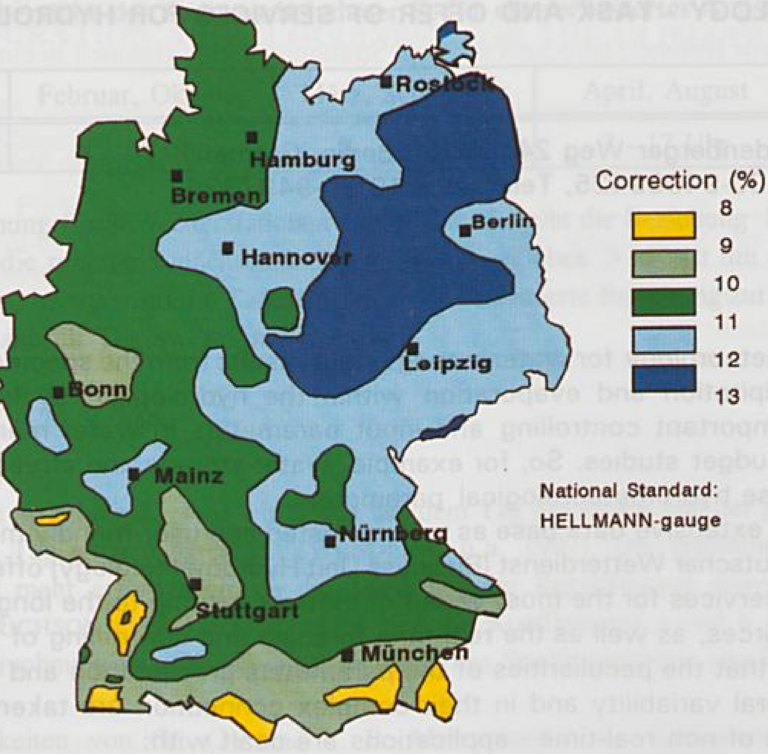
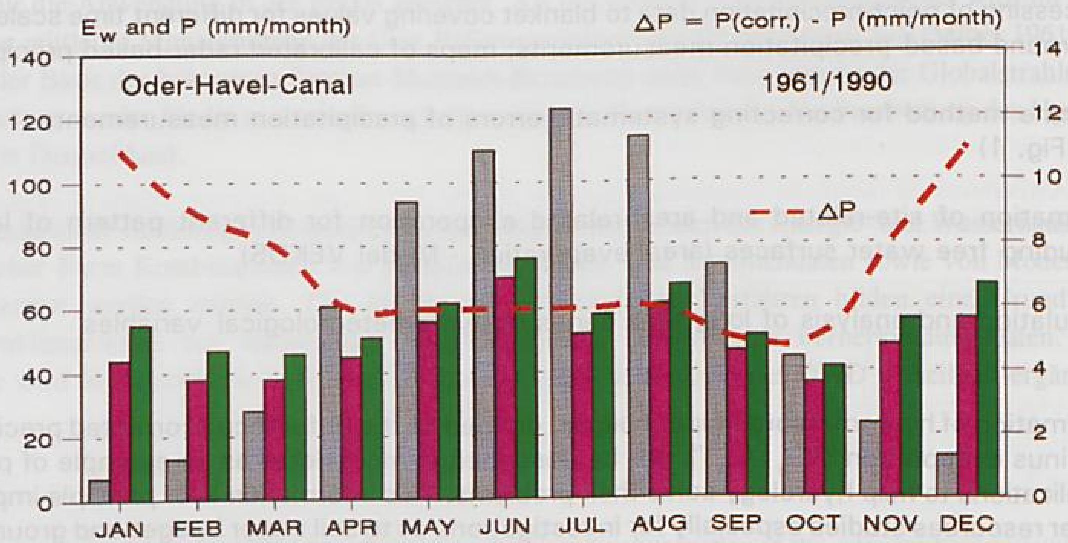


Fig. 1: Long-term mean precipitation values are corrected according to mean monthly and annual systematic errors in per cent (%). For moderate wind-sheltered stations in the Federal Republic of Germany the mean correction (%) of the average annual precipitation total (1961/90) is illustrated as shown.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
E_w	7	13	28	61	94	110	123	114	73	44	23	13
P	44	38	38	45	56	70	52	61	46	36	48	56
P(corr.)	55	47	46	51	62	76	58	67	51	41	56	67

Fig. 2: Shows the mean evaporation totals E_W and the measured and corrected precipitation totals. They demonstrate the different budgets ($P - E_W$) which result from applying measured and corrected precipitation totals. It is obvious that the precipitation totals obtained using the Hellmann gauge (German National Standard) must be corrected for water-management/-water balance studies.

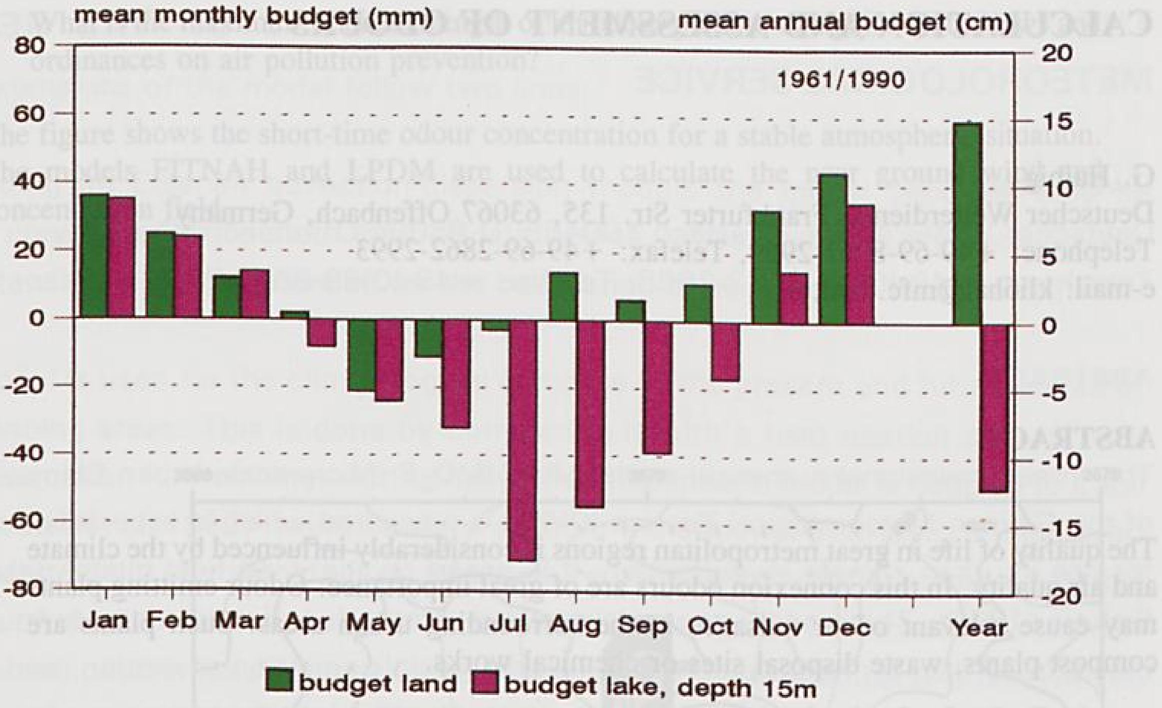


Fig. 3: Shows in comparison the mean annual variation of the hydrometeorological budget (P_{cor} - ET_a; E_W) of an area used agriculturally and a water body (lake or reservoir) under the same climatic conditions (in the Cottbus/Lübbenau area).

CALCULATION AND ASSESSMENT OF ODOURS

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ABSTRACT

The quality of life in great metropolitan regions is considerably influenced by the climate and air quality. In this connexion odours are of great importance: Odour emitting plants may cause relevant odour nuisance in the surrounding urban areas. Such plants are compost plants, waste disposal sites or chemical works.

If a new odour emitting plant is planned following points are to be considered by planners and administrative authorities:

- observance of environmental laws and guidelines ("prevention of relevant odour nuisance")
- maintainance or improvement of the air quality.

The Climate and Environmental Consultancy Group of the German Meteorological Service offers tools to calculate odour dispersion and to assess the relevance of odour nuisance:

- We use measurements (temperature, mean wind field and turbulent components) with the Mobile Units of the German Meteorological Service and calculations with 3D-wind-field models to determine the path of the odour plume over irregular and rough terrain. We apply diagnostic models or the non-hydrostatic model **FITNAH** (**F**low over **I**rregular **T**errain with **N**atural and **A**nthropogenic **H**eat Sources).
- We calculate the odour dispersion with a Gauss-puff model or a **L**agrange **p**artikle **d**ispersion **m**odel (**LPDM**). Special dispersion coefficients are used to acount to the short-time fluctuations of odour perceptions. Weak flow situations can be considered.
- We calculate the frequency of odour perception in order to assess the relevance of odour nuisance. These computations are based on "worst-case" situations or a long-term frequency distribution of dispersion situations.

Following questions can be answered:

- Where in the vicinity of a planned compost plant or rubbish tip odour nuiance will be expected?
- Where is the ideal site of an odour source minimizing the frequency with which odours may be smelt in the surrounding urban areas?

- What is the maximum source strength of an odour plant to comply with the laws and ordinances on air pollution prevention?

The figure shows the short-time odour concentration for a stable atmospheric situation. The models FITNAH and LPDM are used to calculate the near ground wind and concentration field.

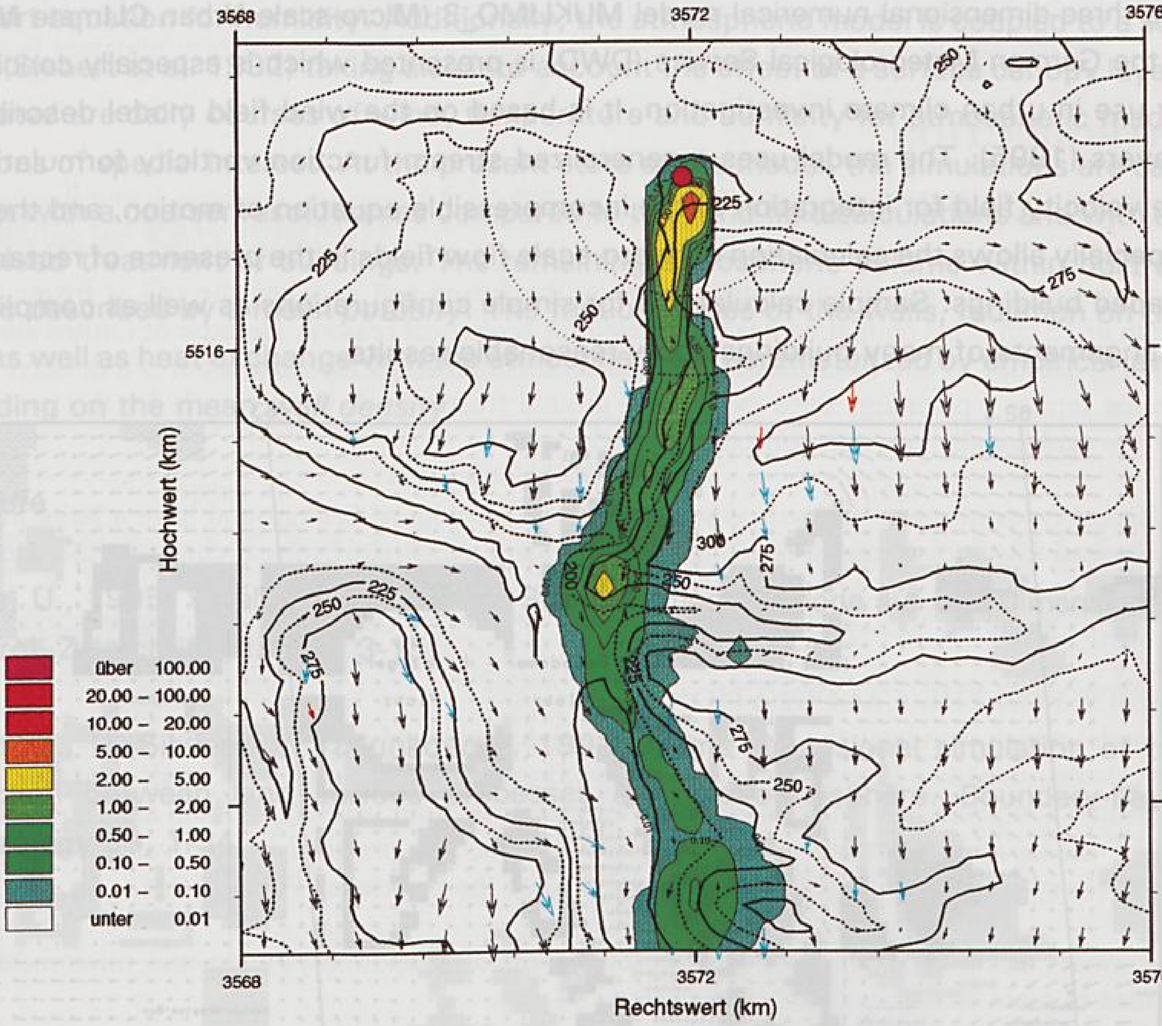

Figure: Calculated wind field and odour plume over irregular terrain. The arrows show the near ground wind direction and velocity; source: 35 m high stack, source strength: 2.5 * 10^7 odour units/h; near ground concentration in odour units/m^3

THE URBAN CLIMATE MODEL MUKLIMO_3 OF THE GERMAN METEOROLOGICAL SERVICE

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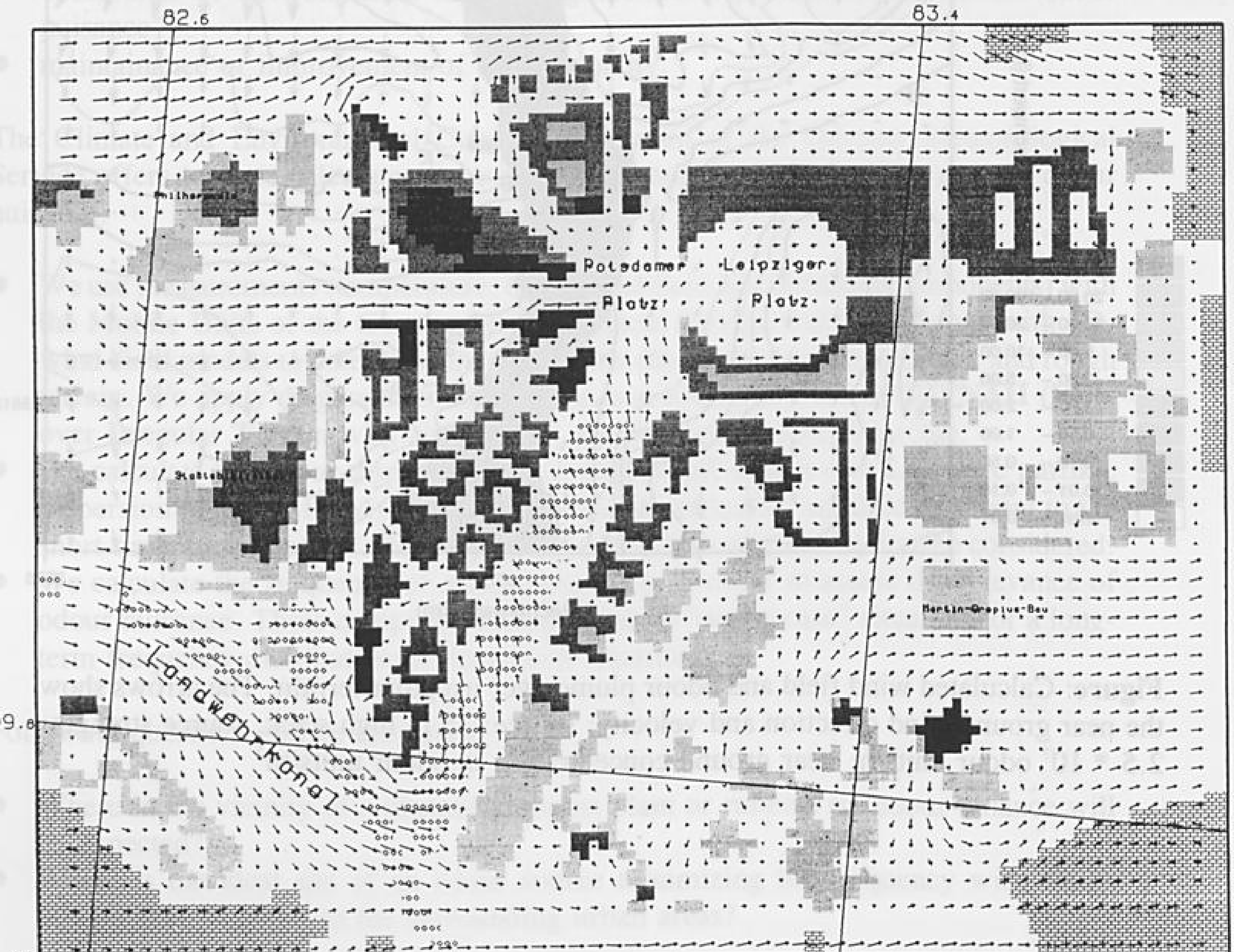
ABSTRACT

The three-dimensional numerical model MUKLIMO_3 (**M**icro-scale **U**rban **CLI**mate **MO**del) of the German Meteorological Service (DWD) is presented which is especially concipated for use in urban climate investigation. It is based on the wind field model described in Sievers (1995). The model uses a generalized stream-function vorticity formulation of the velocity field for integration of the incompressible equation of motion, and thereby, especially allows the calculation of micro-scale flow fields in the presence of rectangular shaped buildings. Sample calculations for simple configurations as well as complicated arrangements of many buildings show reasonable results.



Flow field calculated with MUKLIMO_3

Recent extensions of the model follow two lines:

a) By adding an Eulerian advection-dispersion module the model becomes able to calculate concentration fields of inert air admixtures, whose sources are known. This model extension is mainly intended for the calculation of air pollution due to the traffic.

b) The model is used for the climatological compare of the present and future states of urban planning areas. This is done by completing it with a heat eqation as well as a transport equation for humidity. Additionally, the atmospheric model is coupled to a soil model (Siebert et al. 1992) taking also into account the effect of a surface canopy layer. Calculated are daily courses of wind, temperature and humidity for atmospheric model situations of special interest. At the present state of the model, the simulations are carried out with a coarser resolution as compared to the wind field calculations and with an unresolved treatment of buildings. The remaining atmospheric volume within built-up areas is described by a mean *porosity*. The friction forces of the walls, radiation on the walls as well as heat exchange with the atmosphere are parameterized by empirical laws depending on the mean *wall density*.

Literature

Sievers, U., 1995: Verallgemeinerung der Stromfunktionsmethode auf drei Dimensionen. Meteorol. Zeitschrift, N. F. **4**, 3-15.

Siebert, J., U. Sievers, W. Zdunkowski, 1992: A one-dimensional simulation of the interaction between land surface processes and the atmosphere. Boundary-Layer Meteorology **59**, 1-34.

MODELING AND FORECASTING OF GROUND FROST PENETRATION DEPTHS OF LAND USED FOR AGRICULTURAL PURPOSES - AN ECOLOGICALLY RELEVANT AGROMETEOROLOGICAL FIELD OF WORK

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INTRODUCTION

The application of slurry and other fertilizers is forbidden in the Federal Republic of Germany during the period 15. November - 15. January. In addition the application is not allowed when the soil is snow-covered, when standing-water occurs on the frozen soil or when the soil is frozen down to a depth of 15 cm. This regulation has been stated for ecological reasons. Because of limited slurry storing capacity the day to day determination as well as the forecast of the frost depth is a decisive parameter for the farmer's planning, since even slight ground frosts play a positive role for the tractability and for the ecologically relevant soil compression.

Different types of usage and soil as well as the meteorological background have a large influence on the ground frost which cannot be realized by usual soil temperature measurements in the climatological garden.

BASICS FOR THE CALCULATION

A model which simulates the soil surface energy balance and soil water balance is a prerequisite for the calculation of soil freezing. It is supplied with meteorological data such as air temperature, relative humidity, atmospheric downward radiation components, wind velocity and rain and snow amount. The SVAT model used is the one of Braden (1995) which, as a practical routine version, is integrated in the advisory software AMBER (Löpmeier, 1995) of the Deutscher Wetterdienst.

The model has been developed for the calculation of evapotranspiration and micrometeorological entities in plant stands and the soil.
It simulates the

- absorbed visible, near-infrared and infrared radiation for the plants and the soil surface,
- thermal and hydraulic functions, derived from soil composition,
- soil heat fluxes and temperatures in several layers,
- interception of precipitation, surface runoff and infiltration,
- bulk stomata resistance (depending on plant type, plant age, absorbed visible radiation, water supply),
- soil evaporation, plant transpiration,
- melting of snow cover, as well as
- freezing and melting of water in soil layers.

The model takes into consideration
- soil properties (main particle size fractions, organic matter content),
- type of vegetation and
- morphometric data: plant density, plant height, leaf area index, rooting depth.

The high spatial resolution used for soil discretisation allows the proper representation of soil temperatures in time and depth.
Freezing and melting processes of soil water are considered by stopping temporal changes in the respective soil layer when the freezing point is reached and as long as the recommended heat of freezing or melting is supplied.

As the soil freezing is decisively influenced by the soil water content, it is important to consider the influence of the soil types with their agrometeorological characteristics on the freezing process an to study the soil moisture of different soil layers during the vegetation period and during winter.

RESULTS

The following figure 1 presents measured frost depths in an uncovered soil (loamy sand) and under grassland during the winter 1996/1997.

soil frost depth 1996-97 / Braunschweig

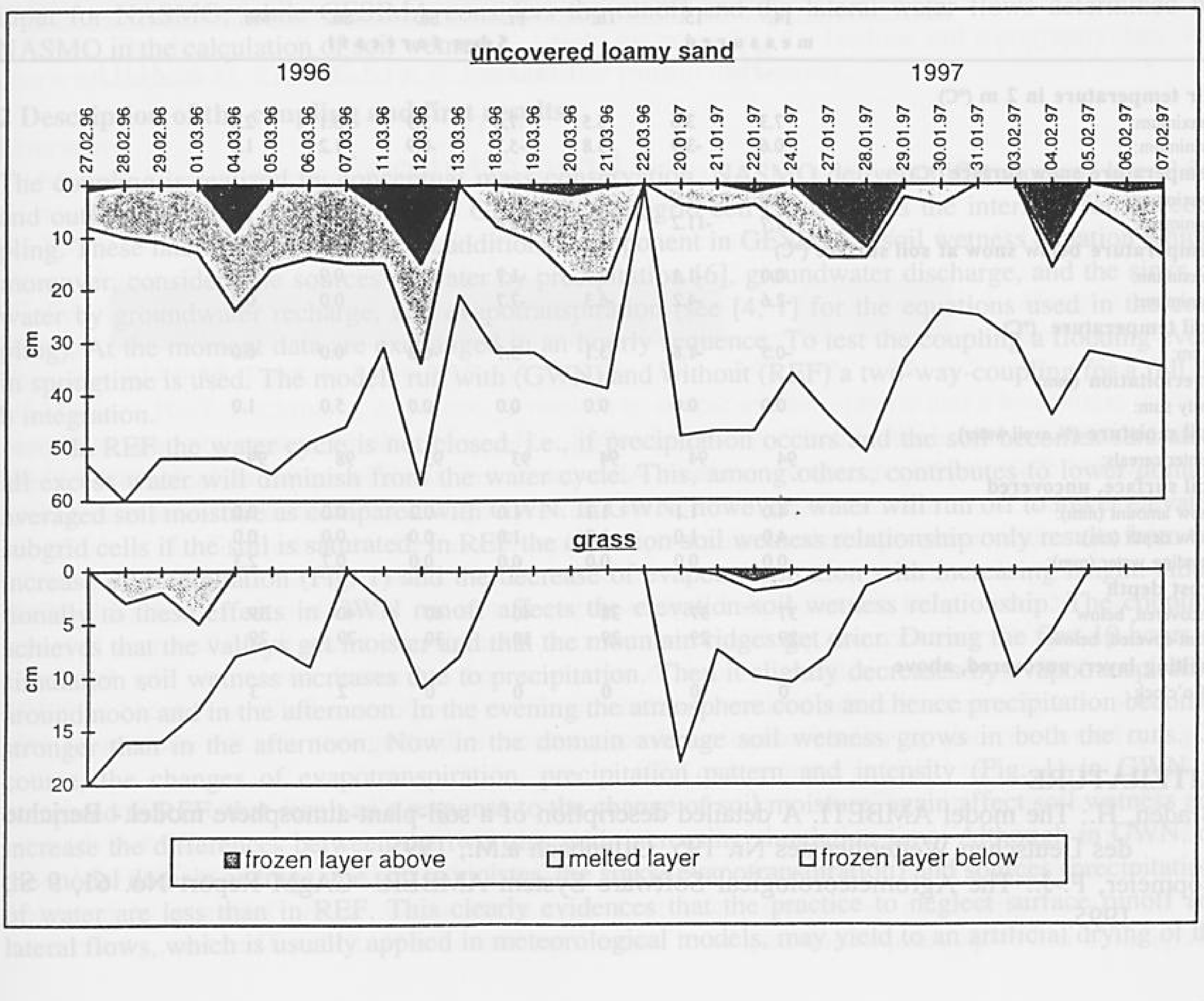
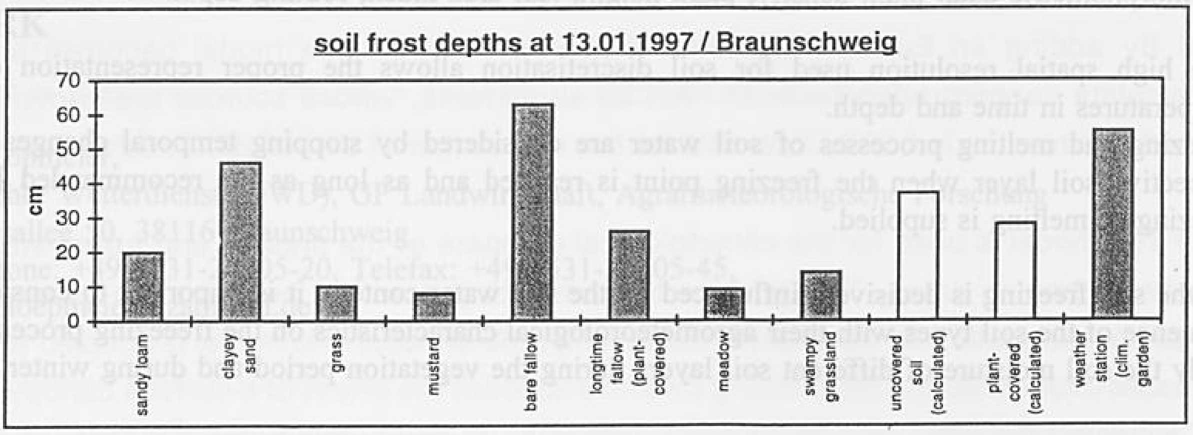


Figure 2 shows large differences in the frost depths depending on the soil type and the type of vegetated coverage for a special day. The black bars are the measured freezing depths, the white bars show simulation results.



Within the framework of the agrometeorological advisory service the soil frost depths are made public by fax and by telephone for the farmer's planning on the basis of a 5 to 7 days' weather forecast. The following table presents an example of predicted agriculturally relevant parameters in the winter, automatically produced by the AMBER advisory software.

Results incl. 5 days forecast of: *16. 1.97 (Thursday)*
for location (station no.): ***Braunschweig*** *(348)*

	14.	15.	Th.	Fr.	Sa.	Su.	Mo.
	measured		5 days forecast				
air temperature in 2 m (°C)							
maximum:	7.3	3.6	5.5	7.6	3.9	3.1	2.8
minimum:	0.6	-3.9	-3.8	-5.7	-0.9	1.2	1.0
temperature snow surface (°C)							
maximum:	0.0	-2.9	-5.7	-1.9	0.0	2.9	2.5
minimum:	-11.7	-11.2	-10.6	-12.4	-1.2	0.0	-1.2
temperature below snow at soil surface (°C)							
maximum:	0.0	-1.1	-2.7	-1.7	0.0	0.9	1.2
minimum:	-2.6	-4.2	-6.3	-7.7	-3.4	0.0	0.0
soil temperature (°C)							
5 cm:	-0.5	-1.8	-3.1	-3.7	-0.8	0.0	0.0
precipitation (mm)							
daily sum:	0.0	0.0	0.0	0.0	0.0	5.0	1.0
soil moisture (% avail.water)							
winter cereals:	94	94	94	93	93	98	99
soil surface, uncovered							
snow amount (mm):	4.0	1.1	1.1	1.0	0.2	0.0	0.0
snow depth (cm):	4.0	1.0	1.0	1.0	0.0	0.0	0.0
standing water (mm):	0.0	0.0	0.0	0.0	0.0	0.7	2.3
frost depth							
uncovered, below	37	37	38	40	40	40	39
plant-covered, below	29	29	29	30	30	29	29
melting layer, uncovered, above							
14 o'clock	0	0	0	0	0	2	3

LITERATURE

Braden, H.: The model AMBETI. A detailed description of a soil-plant-atmosphere model.- Berichte des Deutschen Wetterdienstes Nr. 195, Offenbach a.M., 1995.

Löpmeier, F.-J.: The Agrometeorological Software System AMBER.- CAgM Report No. 61, 9 S., 1995.

On the integration of meteorological model forecasts in a rainfall runoff model and of runoff forecasts in a meteorological model - a coupled hydrologic meteorological package

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1 Introduction

Meteorological models usually neglect lateral flows of soil water, surface runoff, the transport of water by river flow as well as the re- and discharge of the groundwater storage, i.e., the water cycle is not closed. Since precipitation increases with height, neglecting surface runoff and lateral motions in soil water results in an underestimation of soil moisture in river valleys and an overestimation of soil moisture in mountains. Such wrong distributions of dry and wet surfaces, however, may appreciably affect the local water supply to the atmosphere and the quality of numerical weather prediction. To overcome these problems hydrologic and meteorological concepts have to be matched by coupling hydrologic and meteorological models.

Although for such a coupling more physically based hydrologic models should be preferred, in a first attempt the hydrologic model NASMO (**N**iederschlag-**A**bfluß-**S**imulations**MO**dell; [1]) and the Leipzig's version of the non-hydrostatic model GESIMA (**GE**esthacht's **SI**mulation **M**odel of the **A**tmosphere; e.g., [2, 3]) are coupled [4]. In doing so, the effective rain predicted by GESIMA serves as input for NASMO, while GESIMA considers the runoff and the lateral water flows determined by NASMO in the calculation of soil wetness.

2 Description of the coupling and first results

The coupling is realized by conceptual mass conservation. NASMO delivers differences of lateral in- and outflow for the 1 x 1 km^2 area of GESIMA's subgrid cell [5] which is the interface for the coupling. These lateral flows serve as an additional component in GESIMA's soil wetness equation which, moreover, considers the sources of water by precipitation [6], groundwater discharge, and the sinks of water by groundwater recharge, and evapotranspiration (see [4, 1] for the equations used in the coupling). At the moment data are exchanged in an hourly sequence. To test the coupling a flooding event in springtime is used. The models run with (GWN) and without (REF) a two-way-coupling for a full 24 h integration.

In REF the water cycle is not closed, i.e., if precipitation occurs and the soil becomes saturated, all excess water will diminish from the water cycle. This, among others, contributes to lower domain averaged soil moisture as compared with GWN. In GWN, however, water will run off to lower elevated subgrid cells if the soil is saturated. In REF the elevation-soil wetness relationship only results from the increase of precipitation (Fig. 1) and the decrease of evapotranspiration with increasing height. Additionally to these effects in GWN runoff affects the elevation-soil wetness relationship. The coupling achieves that the valleys get moister and that the mountain ridges get drier. During the first 10 hours of simulation soil wetness increases due to precipitation. Then it slightly decreases by evapotranspiration around noon and in the afternoon. In the evening the atmosphere cools and hence precipitation becomes stronger than in the afternoon. Now in the domain average soil wetness grows in both the runs. Of course, the changes of evapotranspiration, precipitation pattern and intensity (Fig. 1) in GWN as compared to REF, that result as a response to the change of soil moisture, again affect soil wetness and increase the differences between the two runs with increasing simulation time. Although in GWN, on the model domain average, the soil is moister, the sinks (evapotranspiration) and sources (precipitation) of water are less than in REF. This clearly evidences that the practice to neglect surface runoff and lateral flows, which is usually applied in meteorological models, may yield to an artificial drying of the underlying surface and a reduced moisture availability. The coupling, presented here, may be regarded as a possible step to improve the prediction of soil moisture in meteorological models.

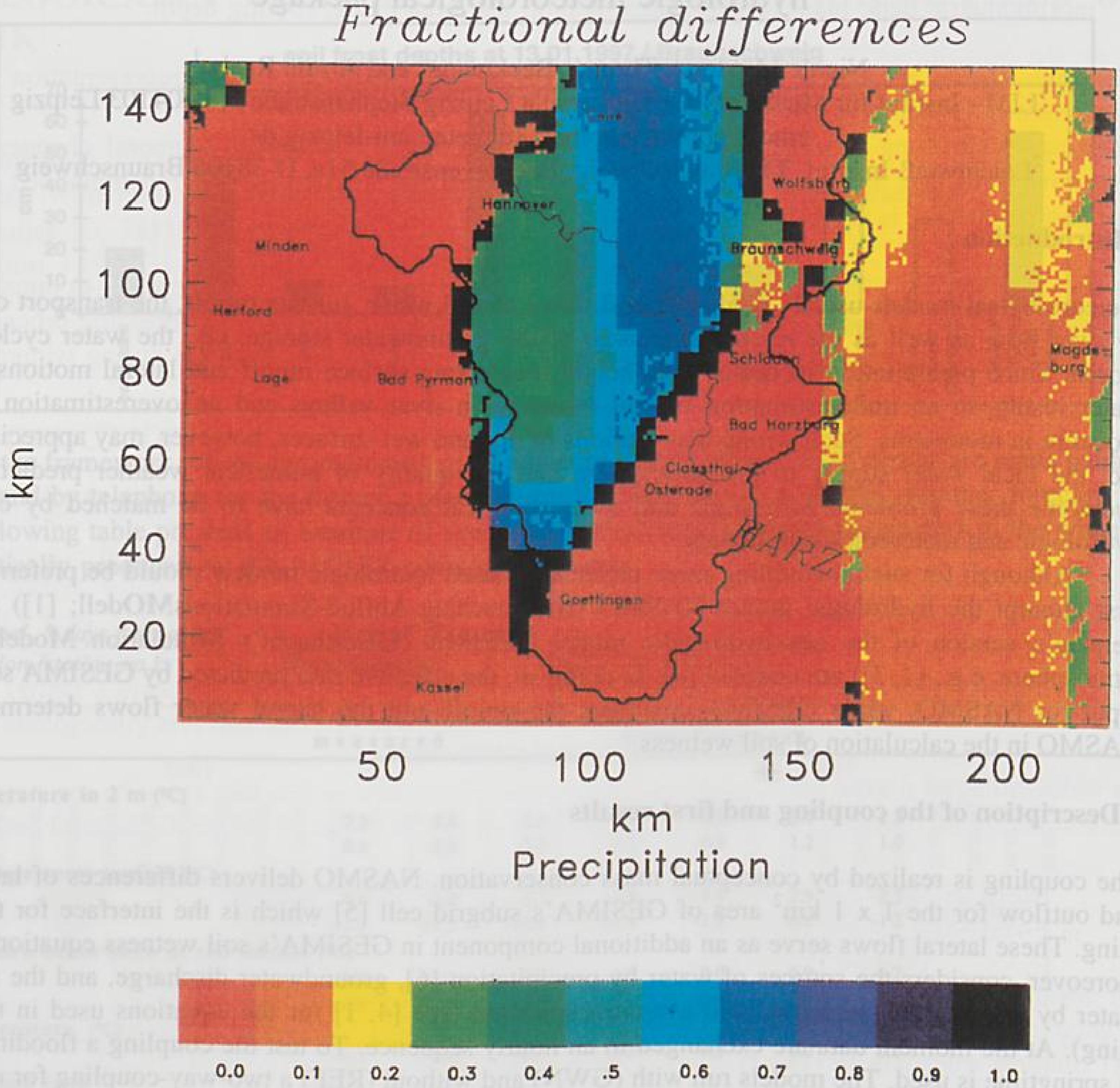

FIG. 1 Fractional differences, fd = $(P_{REF} - P_{GWN}) / (P_{REF} + P_{GWN})$, of precipitation at noon after 12 hours of simulation. The coupling area is the southern Aller catchment (thick lines) which includes the Leine basin (thin lines). Note that the differences outside the coupling area result from differences in advection of temperature, water vapor, cloud and precipitating particles.

Comparison of the coupled and uncoupled regions shows that in the basin there is a remarkable effect of the coupling, for instance, on predicted precipitation. Outside the basin the differences between GWN and REF result from differences due to advection and numerical truncation. The fractional difference of 1 illustrates that the horizontal extension of the precipitation fields is reduced in GWN (Fig. 1). Moreover, only positive fractional differences occur indicating that also the intensity of precipitation is reduced in GWN as compared to REF.

Despite precipitation (Fig. 1), and evapotranspiration rates as well as soil wetness differ a factor of 2 and more at some locations, the runoff predicted by NASMO will be quite insensitive if the precipitation rate is less 2 mm/d, which is the case in the considered basin for this test case. This evidences that on a short-time scale (~ several hours to 1 day) slight errors in the intensity of predicted precipitation and evapotranspiration may be of minor importance for NASMO. Therefore, greater time steps seem to be possible for the coupling. A time step of 6 h will be tested in the near future. Note that a misprediction of the distribution and intensity of precipitation plays a more important role than the differences between GWN and REF, and, consequently, leads to a worse forecast of runoff as compared to a run using measured precipitation data as input.

In meteorological modeling practice runoff is often defined as the difference between precipitation and evapotranspiration. Comparison the runoff determined according to this definition with the runoff provided by NASMO shows appreciable differences with respect to pattern and intensity.

3. Conclusions and outlook

Although this case study was only performed for a 24h integration reasonable tendencies of the impact of the coupling on the meteorological forecast are found so that for long term simulations appreciable impacts on the predicted meteorological quantities have to be expected which should also lead to an improvement of the meteorological forecasts. There is still a lot of work to be done in the future before such couplings can be applied routinely. First of all, some still remaining inconsistencies between the models have to be removed. Moreover, up to now, the models are only loosely coupled on an hourly basis via exchange of data. To improve the simulation time, and the performance as well as to remove the inconsistencies between the models, the hydrologic part has to be directly implemented as a subroutine of GESIMA. Moreover, it has to be tested which and which combination of components (soil moisture, evapotranspiration, precipitation, lateral differences of flow, etc.) are the best to realize the coupling. This has to be done in close connection with verification.

Acknowledgments
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Literature

[1] Maniak, U.: Gitterpunktgestütztes Flußgebietsmodell als Abflußmodul eines Wasserhaushalts- bzw. Klimamodells. Zwischenbericht (1996).
[2] Kapitza, H., D.P. Eppel: The non-hydrostatic mesoscale model GESIMA. Part I: Dynamical equations and tests. Contr. Atmos. Phys. 65 (1992), 129-146.
[3] Eppel, D.P., H. Kapitza, M. Claussen, D. Jacob, W. Koch, L. Levkov, H.-T. Mengelkamp, N. Werrmann: The non-hydrostatic mesoscale model GESIMA. Part II: Parameterizations and applications. Contr. Atmos. Phys. 68 (1995), 15-41.
[4] Mölders, N., T. Beckmann, A. Raabe: A module to couple an atmospheric and a hydrologic model - description and preliminary results. Wiss. Mitt., Meteorologische Arbeiten aus Leipzig 4 (1996), 77-89.
[5] Mölders, N., A. Raabe, G. Tetzlaff: A comparison of two strategies on land surface heterogeneity used in a mesoscale β meteorological model. Tellus 48A (1996), 733-749.
[6] Mölders, N., G. Kramm, M. Laube, A. Raabe: On the influence of bulk-parameterization schemes of cloud microphysics on the predicted water-cycle relevant quantities - a case study. Met. Zeitschr. 6 (1997), 21-32.

ESTIMATION OF THE YEAR-TO-YEAR VARIABILITY OF GRASSLAND PRODUCTION IN FRANCE

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ABSTRACT

The French Ministry of Agriculture, through its central department for sample survey and statistical studies (SCEES), requested the national institute for agronomic research (INRA) and METEO-FRANCE the assessment of the year-to-year variability of grassland production in France. This information will be used in order to pay the farmers public subsidies, in case of crisis (local or global drought).

To answer to this request, INRA and METEO-FRANCE will both realize a system for real-time predisction of grassland production at national scale. It will be based on the INRA crop model STICS and will be applied on about 200 « small grassland areas » (PRF). The software will be developed in the next two years and a model will be realized, on two test areas (Poitou-Charentes and Midi-Pyrénées), until the end of 1997.

Several studies must be carried out to obtain these results: determination of the geographical elementary areas, on which the calculations will be done; interpolation of the meteorological data for each area; integration of the several kinds of grasslands, ground and farming practices; introduction of a nitrate nutrition index.

At the end, the output results will be integrated at different time end space scales. The global system will work on an operational way in 1999.

Le Service Central des Enquêtes et Etudes Statistiques (SCEES) du Ministère de l'Agriculture de la Pêche et de l'Alimentation a exprimé le besoin de connaître l'estimation des variations inter-annuelles de la production fourragère prairiale, à l'échelle de la France et à la résolution de la Petite Région Fourragère (PRF). Pour y répondre, l'INRA et METEO-FRANCE ont conjointement proposé la mise au point d'un système informatique intégrant un modèle de production fourragère (STICS-Prairies), développé par l'INRA. Les objectifs sont d'identifier, dans l'espace et dans le temps, les situations de crise (baisses de production instantanée significatives imputables à des conditions pédoclimatiques défavorables) et de fournir des estimations de la production fourragère annuelle globale ou de ses variations par rapport à la normale.

L'objectif est d'aboutir à un système opérationnel dès 1999. Les années 1997 et 1998 seront consacrées aux actions de développement et de mise au point en amont, réalisées par l'INRA et METEO-FRANCE.

Le projet, qui vient de démarrer durant le premier semestre 1997, a été découpé en phases logiques et globalement chronologiques. L'un des premiers points concerne l étude des découpages géographiques à prendre en compte, selon les paramètres introduits dans le système. A l'issue de cette étape, l'étude et le choix de la méthode d'interpolation des données météorologiques nécessaires en entrée du modèle seront effectués. Simultanément, l'adaptation du modèle STICS aux différents fourrages sera réalisée, ainsi que sa validation pour l'ensemble de la France. L'ensemble de ces recherches permettra de mettre au point l'architecture globale du système. Il sera alors possible de réaliser une maquette informatique, démontrant le fonctionnement complet du système, sur deux régions test: Poitou-Charentes et Midi-Pyrénées. Enfin, pour passer au modèle global sur toute la France, les données issues d'une enquête terrain du SCEES (pratiques culturales, répartition des fourrages) seront introduites dans le système, pour aboutir à un fonctionnement en temps quasi-réel (fin de la décade en cours) fin 1999. Ces différentes étapes sont détaillées dans la suite de ce document.

L'étude du fond cartographique est indispensable pour connaître la structure géographique des zones sur lesquelles le système fonctionnera. En effet, avant de choisir la méthode d'interpolation spatiale des données climatiques, il est nécessaire d'examiner les recoupements de frontières entre les PRF, la carte des sols au millionième et la position des stations climatiques disponibles (en fonction des paramètres qui y sont mesurés).
.La figure 1 montre, sur la région Poitou-Charentes, la complexité de ces découpages thématiques.

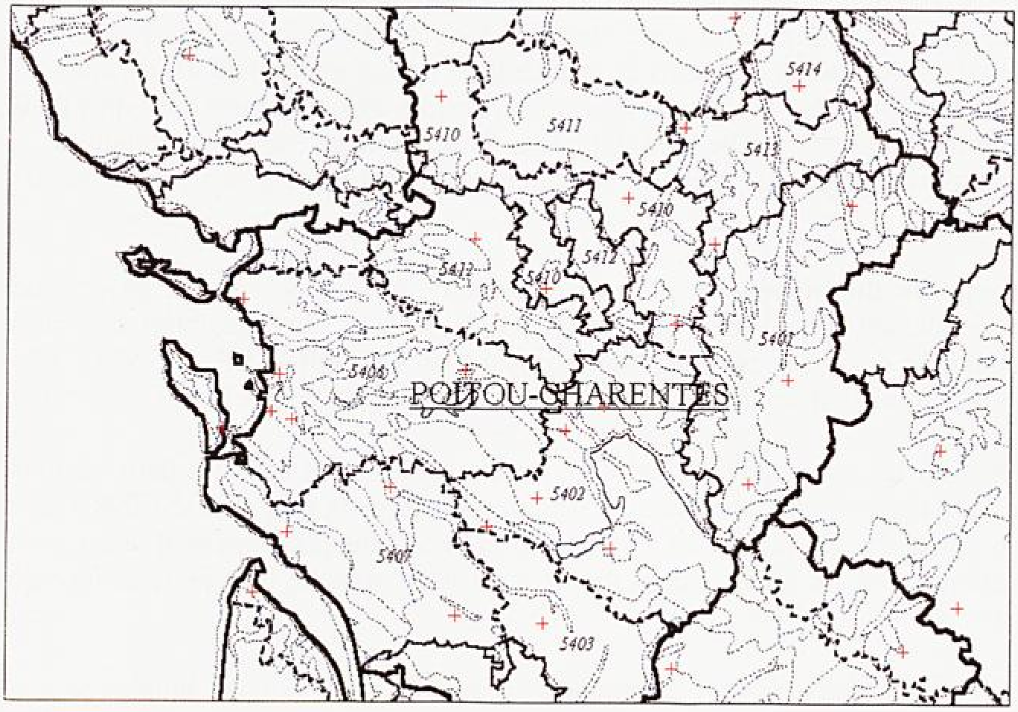

Figure 1: Tracés superposés, pour la région Poitou-Charentes, des PRF (lignes tiretées avec numéros associés en italique), des types de sols (lignes pointillées) et des stations météorologiques mesurant l'ETP en 1997 (croix)

L'interpolation des données météorologiques doit être réalisée pour deux cas de figure: l'interpolation spatiale des données météorologiques nécessaires en entrée du modèle pour qu'il fonctionne en temps quasi-réel et l'interpolation spatiale des données météorologiques historiques pour faire tourner le modèle sur plusieurs années et calculer des statistiques de productions fourragères simulées. Pour l'élaboration de ces statistiques, la période retenue est 1982-1995.
Plusieurs approches vont être étudiées: l'attribution des données locales des stations météorologiques existantes aux PRF les plus proches, l'interpolation par krigeage qui serait applicable pour l'ensemble des applications (statistique puis temps quasi-réel).
En tout état de cause, cette étude devra être réalisée par paramètre météorologique. Chaque méthode d'interpolation sera évaluée en fonction de l'impact sur le résultat issu du modèle, en essayant d'optimiser le couple: complexité et temps d'interpolation / validité et précision du résultat.

L'adaptation du modèle STICS aux différents contextes d'application prévus doit être réalisée par l'INRA. En effet, il existe actuellement un modèle de simulation de la production de prairies (fétuque ou ray-grass) en cultures pures, sous hypothèse d'un couvert bien établi (pas de variation de profondeur du front racinaire). Ce modèle, STICS-Prairie, a été mis au point conjointement par l'Unité d'Agronomie de Lusignan et l'Unité de Bioclimatologie d'Avignon. Il permet de simuler, à un pas de temps journalier, le

fonctionnement d'une culture à l'optimum ou le fonctionnement sous contrainte hydrique, grâce à un module simulant l'absorption d'eau par les racines. La conduite de la prairie est limitée au fauchage et la contrainte azotée n'y est actuellement pas prise en compte.
Ce modèle a été calé sur des résultats expérimentaux à l'échelle de la parcelle, dans des conditions de climat océanique à faible altitude (Lusignan, Rennes). Le but est de le faire passer de son domaine actuel d'application à la simulation de variations interannuelles de productions à l'échelle des PRF sur l'ensemble du territoire. Pour ce faire, plusieurs actions doivent être réalisées: collecter les données nécessaires au calage, généraliser le calage de la version locale à des conditions pédoclimatiques plus larges, prendre en compte le niveau d'alimentation azotée et la définition d'un indicateur d'indice azoté simple et enfin. intégrer la diversification des couverts prairiaux et des modes de conduite simulables par le modèle.

L'établissement de la base de données agroclimatiques consistera alors à la mise au point de la structure de base permettant d'attribuer à chacune des PRF l'ensemble des paramètres nécessaires au fonctionnement du modèle. Cette structure devra permettre d'intégrer sur l'ensemble de la France: les valeurs des paramètres du climat (ou des coefficients de pondération pour l'interpolation), les caractéristiques hydriques des différents types de sol retenus, les caractéristiques agronomiques des types prairiaux présents (niveau de nutrition azotée, mode d'exploitation) ainsi que leurs superficies relatives. A terme, l'alimentation de cette base devra être réalisée, pour l'ensemble des PRF. à partir des résultats de l'enquête du SCEES.

La réalisation d'une maquette du modèle, appliquée à deux régions test, prendra en compte l'adaptation du modèle, fonctionnant actuellement sous WINDOWS, et la gestion des interfaces entre les systèmes (utilisation conjointe de systèmes informatiques multiples: SIG, ORACLE et UNIX). Elle assurera l'extraction et/ou la compilation de la partie de la base de données concernée puis l'intégration à différentes échelles.
Cette maquette sera réalisée sur les types prairiaux et les types de sol présents dans les deux régions choisies: Poitou-Charentes et Midi-Pyrénées. Le choix s'est porté sur ces deux régions car l'INRA dispose de nombreux jeux de données pour valider les résultats du modèle dans la première et la seconde permettra de tester le fonctionnement du système dans un contexte géographique difficile (présence de relief, types de sol très disparates).

Deux enquêtes du SCEES seront réalisées pour déterminer, sur les PRF, des critères simples renseignant sur les niveaux d'alimentation azotée et les modes d'exploitation des prairies, dans le but d'initialiser le modèle. Dans un premier temps, une enquête pilote sur les deux régions (Poitou-Charentes et Piémont Pyrénéen) sera réalisée en octobre 1997. Dans un second temps, l'enquête sera effectuée sur l'ensemble de la France, à l'automne 1998. Les données obtenues seront intégrées dans le système. pour passer en mode opérationnel dans le courant de l'année 1999.

CHARACTERIZATION OF THE CLIMATE IN FRANCE FOR ROAD DRAINAGE PURPOSES

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ABSTRACT

Climate indexes are proposed in order to characterize the climate in France for road drainage purposes.

This study was elaborated by Météo-France on request of the French Centre of Technical Studies of Equipment.

Two indexes (the thermal efficiency and the humidity index), which were performed by Thornthwaite (I) and tested in the US by the Federal Highway Administration (II), are first calculated on 432 measurement points over France for the period 1976-1995. The two indexes give a good indication to characterize the climate, as far as humidity and temperature are concerned.

As the French Centre of Technical Studies of Equipment is used to another index (the frost index) to take into account thermal phenomena, it was decided to characterize the climate for drainage purposes with the humidity index and the frost index.

1. INTRODUCTION

In order to characterize the climate in France for road drainage purposes, meteorological indexes, which have been performed by Thornthwaite (I) and tested in the US for road drainage purposes by the Federal Highway Administration (II), are first calculated. These indexes take into account the effects of temperature and humidity.

This study was elaborated by Météo-France on the request of the French Centre of Technical Studies of Equipment. The aim of the study is to know whether the values of the indexes proposed in the US allow to determine climatic areas over France, which have a significance for road drainage purposes.

The calculations are performed on 432 measurement points over France for a period of 20 years (between 1976 and 1995).

2. CALCULATION OF THE INDEXES

Two indexes are proposed by Thornthwaite (I) to characterize the climate : the thermal efficiency and the humidity index. Their calculation need only to have at one's disposal two monthly meteorological parameters : the monthly average of the daily mean temperature and the monthly total amount of precipitation. This allows to calculate them on a large number of measurement points. The calculation of the indexes needs first to calculate the monthly potential evapotranspiration, which is function of the monthly average of temperature and of the duration of the day depending on latitude according to the empirical Thornthwaite's formula.

2.a. The thermal efficiency

The thermal efficiency is the ratio between the potential evapotranspiration in summer (for the months of June, July and August) and the yearly potential evapotranspiration.

High values of thermal efficiency are observed when the contrast of temperature between summer and winter is important, that is to say in continental areas.

The risk of deficiency for roads is more important in areas where high values of thermal efficiency are observed.

In France (figure 1), high values are observed on the East of the country and on mountains, whereas low values are observed on the western part of France, particularly over Britain and Normandy, which are associated with an oceanic climate.

Figure 1 : THERMAL EFFICIENCY

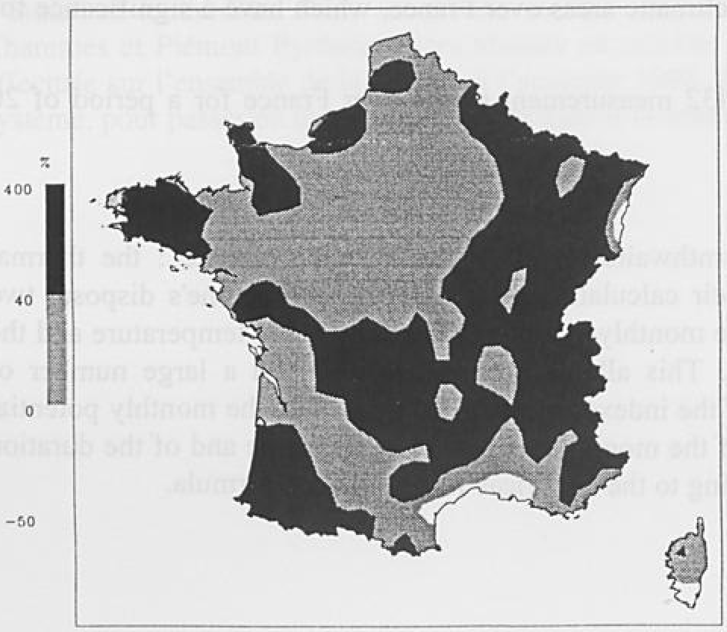
2.b. The humidity index

The humidity index (IHU) takes into account the water surplus (S) or deficiency (D) in the soil, and is defined with :

$$IHU = 100\,(S - 0.6\,D) / PE(yearly)$$

where PE(yearly) is the yearly potential evapotranspiration, with $D = PE - RR$ when $PE > RR$ (0 otherwise) and $S = RR - PE$ when $RR > PE$ (0 otherwise), where RR is the monthly total amount of precipitation, PE is the monthly potential evapotranspiration.

Figure 2 : HUMIDITY INDEX



The weight of the water deficiency is 0.6 because studies give the result that a surplus of 6 cm will counteract a deficiency of 10 cm.

The index is added up for the twelve months of the year. It is calculated for each year and averaged on the 20 years of the study.

High values are associated with wet areas, where the risk of deficiency for roads is more important.

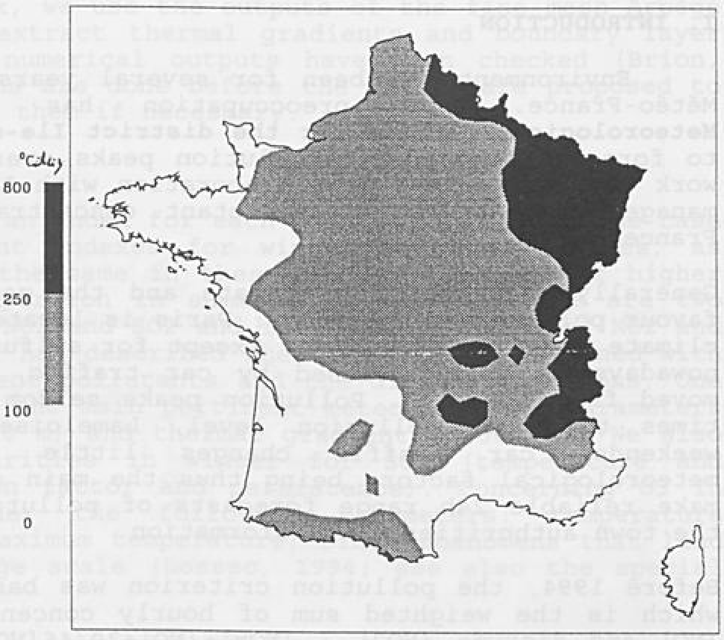
High values (figure 2) are observed over Britain, Normandy and on mountains areas. The Mediterranean coasts, the South of Corsica and the plain of Alsace are associated with low values.

3. CHARACTERIZATION OF THE CLIMATE

The two indexes, which were proposed in the US allow to characterize the climate over France but it appears that another index, the frost index, which was already calculated over France, gives a somewhat different indication of the thermal phenomena for road purposes.

The frost index calculates the intensity of the frost by adding up the daily averages of temperature below 0°C. The calculation of this index was elaborated by the French Centre of Technical Study of Equipment (III) according to a specific norm (IV).

Figure 3 : FROST INDEX



This index takes high values on the East of France and on mountains, whereas coastal areas are associated with low values (figure 3). This index is quite different from the thermal efficiency, as far as Mediterranean coasts are concerned (figures 1 and 3).

It was decided to use the humidity and the frost index to characterize the climate over France for road drainage purposes.

These indexes should be combined with the composition of the soil to propose a system of notation, which gives a more complete indication of the risk of deficiency for roads.

4. CONCLUDING REMARKS

The two indexes proposed on the US allow to characterize the climate in France but it was decided to replace the thermal efficiency by the frost index.

The climate is thus characterized with the humidity index and the frost index.

Nevertheless, the climate is only one aspect, which is to take into account for road drainage purposes. The climate indexes should be associated with the composition of the soil to give a more complete indication of the risk of deficiency for road drainage purposes.

REFERENCES

(I) Thornthwaite, C.W., 1948 :"An approach toward a rational classification of climate", *Geographical Review, volume 38 (pp 55-94).*

(II) Report of Federal Highway Administration, 1983 : "A pavement moisture accelerated distress (MAD) identification system", *FHWA / RD-81/079 September 1981.*

(III) C.E.T.E de l'Est : "Indices de gel", *Dossier n° 91-610.*

(IV) "Terminologie relative au calcul de dimensionnement des chaussées": Norme NF P 98-080-1.

FORECASTING ATMOSPHERIC POLLUTION OVER ILE-DE-FRANCE

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I. INTRODUCTION

Environment has been for several years one of the main concerns of Météo-France. This preoccupation has lead the **DIRIC (Regional Meteorological Service for the district Ile-de-France, i. e. around Paris)** to forecast atmospheric pollution peaks over Paris and its suburbs. This work was carried out in collaboration with **AIRPARIF**, the association which manages the network of pollutant concentration measurements in Ile-de-France.

Generally speaking, the climate and the geographical situation of Paris favour pollutant dispersion : Paris is located in a plain, with an oceanic climate and frequent winds. Except for sulfur dioxyde (SO2), air pollution nowadays is mainly caused by car traffic, since industrial plants have moved from the city. Pollution peaks seldom occur but may be severe (ten times the mean pollution level, Lameloise et al., 1992). Except for weekends, car traffic changes little from one day to another, meteorological factors being thus the main cause of variation. We try to make reliable 24h range forecasts of pollution peaks in order to provide the town authorities with information.

Before 1994, the pollution criterion was based on the daily mean of NOx, which is the weighted sum of hourly concentrations of nitrogen monoxyde (NO) and dioxyde (NO2) : $[NOx] = [NO] + 30/46 [NO2]$. A polluted day was thus defined as a day where the daily mean on NOx is beyond 130 $\mu g/m3$.

Since 1994, the Préfecture de Police de Paris, which is the autority in charge if the management of air quality in the parisian district and has defined 3 threshold levels for 3 pollutants (O3, SO2, NO2). The threshold values are given in Table 1. The first level corresponds to administrative concertation, and is frequent enough to be dealt with by statistical techniques, the 2nd and 3rd one (public information or traffic restriction) are rather seldom. They are based on hourly values, which makes the forecast difficult, and are validated only if two measurement points are beyond the threshold level at the same time. The AIRPARIF measurement network is presented on the Figure, its size increased between 1988 and 1993, thus leading to biases in a statistical study. The number of measuring stations is the following at the end of 1994 : SO2 (53), NOx (38), O3 (15).

II. STATISTICAL METHOD

For each pollutant, a pollution index has been defined in terms of meteorogical, emission and persistence parameters. These meteorological parameters are defined after carrying out some synoptic case studies related to pollution peaks : for winter situations, they are summarized in Menin (1991) and the 31 july 1992 summer photo-oxydant episode is described in Lossec (1994). The results of these case studies were then generalized by statistical methods to a ten years (for NOx) or five years (for hourly peaks, subjected to quality control) training sample. For ozone, we also use the relevant bibliography (Clark and Karl, 1982; Toupance, 1988).

The statistical method used is multivariate discriminant analysis which is a robust method, adequate to a regional scale prognosis of an event (W.M.O., 1992; Der Megreditchian, 1988). So one finds a linear combination of meteorological, emission and persistence parameters, which is called the discriminant function; one can then tell that a level 1 alert should or not occur, according to the values of this function which we call index. The dependant variables are selected using a stepwise upward selection scheme.

In order to make a 24 h range forecast, we use the perfect prognosis assumption : discriminant functions are fitted on observations, and, on a day to day operative basis, numerical weather predictions of the same parameter will be used. With this method one can use a large observations data set, although numerical weather model archives are short, and the results are not affected by changes in numerical weather models. The outputs of numerical models used in the statistical prediction can be improved by using Model Output Statitics, or Kalman-filter technique.

In an operational framework, we use the outputs of the fine mesh Arpège numerical model in order to extract thermal gradients and boundary layer winds. The quality of these numerical outputs have been checked (Brion, 1992), so that bias corrections are done before the values are proposed to the forecaster, who can modify them if necessary.

III. RESULTS AND DISCUSSION

It is necessary to define an index for each pollutant, and, in the case of NO2, to make two different indexes for winter and summer times, as pollution mechanisms are not the same in these seasons, because of higher photochemistry and higher dispersion in summer. In winter, there are two pollutants to be considered : NO2 and SO2 and in summer we consider NO2 and O3. The previous ECAM 95 paper has described the main results obtained with this technique for the different pollutants and the different seasons. One has to mention that generally the main pertinent meteorological parameters are : low level wind speed (10 m) and thermal gradient (0-300 m). We also have the following particularities in winter for SO2 (temperature and persistence) and NO2 (emission factor and persistence). Concerning O3 in summer, we have to consider the following parameters: temperature stability, 850 hPa wind and maximum temperature, since phenomena that lead to ozone peak occur at a large scale (Lossec, 1994; see also the special case on 27 April 1996).

REFERENCES

Clark T. L., and T. R. Karl, 1982 : Application of prognostic meteorological variables to forecasts of daily maximum one hour ozone concentrations in Northern United States. J. Appl. Meteorol., 21, 1662-1671.

Brion D., 1992 : Prévision d'un indice de dispersion à Paris à partir de paramètres météorologiques. Note de la DIRIC No 2.

Der Megreditchian, G. 1988 : Eléments de l'analyse discriminante. Théorie et pratique. Note de l'ENM Paris 1988.

Lameloise Ph., Renaudot C., Brion D., Javelle J.P. et Lossec B., 1992 : Prévision d'un indice de pollution atmosphérique urbaine en fonction des conditions météorologiques. Congrès mondial sur l'Air Pur (Montréal 30 août - 4 septembre 1992).

Lossec B., 1994 : Situation météorologique et pollution photo-oxydante : l'épisode remarquable du 29 juillet au 1er août 1992. La Météorologie, 8ème série n° 8, 23-35.

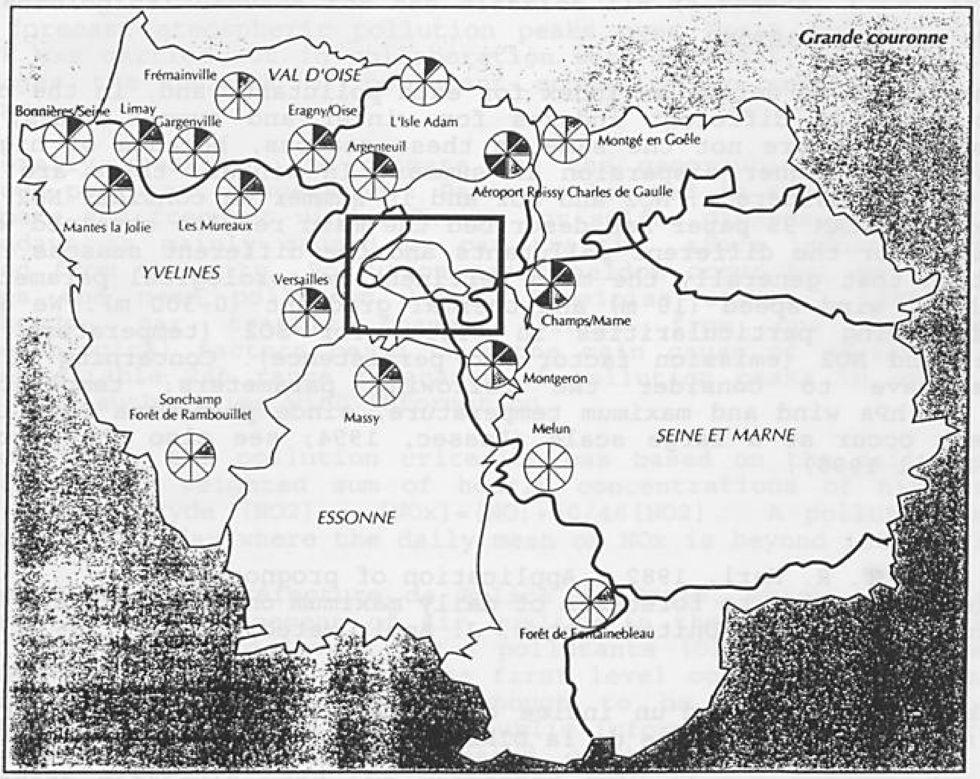
Menin V., 1991 : Prévision d'un indice de pollution en région parisienne relatif aux conditions météorologiques. DEA de Statistiques Université Paris VI sous la direction de J.P. Javelle.

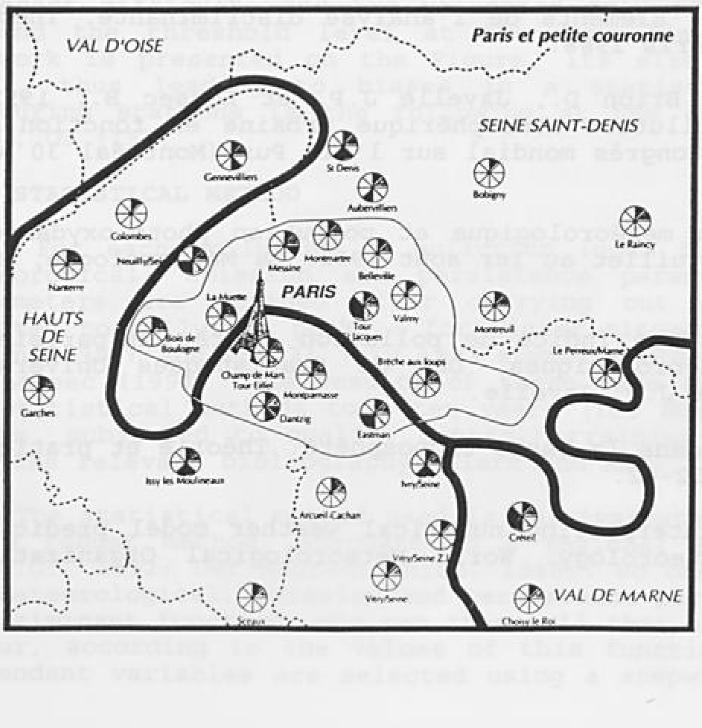
Toupance G., 1988 : L'ozone dans la basse troposphère. Théorie et pratique. Pollution Atmosphérique, p. 32-42.

W.M.O., 1992 : Methods of interpreting numerical weather model prediction output for aeronautical meteorology. World Meteorological Organization, Technical Note N° 195.

Table 1 : Concentration thresholds of the alert system in Paris.

	NO_2	SO_2	Ozone
Stage 1 : Authorities information	200	130	200
Stage 2 : Public and authorities information	300	180	350
Stage 3 : Alert	400	360	600





NUMERICAL WEATHER PREDICTION AT THE DEUTSCHER WETTERDIENST (DWD)

- CURRENT SYSTEM -

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ABSTRACT

The current operational numerical weather prediction (NWP) system of the DWD consists of a model chain comprising the Global-Modell (GM) for large-scale predictions, the regional-scale Europa-Modell (EM) for the synoptic and meso-α scale, and the high-resolution meso-ß scale Deutschland-Modell (DM) as the main forecasting tool for Germany (Tab. 1). The DM has been developed in close cooperation with the Swiss Meteorological Institute (SMI, Zürich).

The data assimilations GA, EA and DA for the models GM, EM and DM proceed as three parallel streams which are coupled only via the boundary data, namely GM for EM and EM for DM. The analysis of the mass and wind fields is based upon the global ECMWF analysis scheme and has been extended to allow for the analysis of limited domains for EM and DM. The 6-hourly intermittent data assimilation uses 3D multivariate optimal interpolation (OI) for the analysis of the mass and wind field increments. The following observations enter the analysis: SYNOP, SHIP, TEMP, PILOT, SATOB, SATEM, AIREP and ASDAR with an observation time window of 3 hours around the four analyses at 00, 06, 12 and 18 UTC.

The Global-Modell (GM) has been derived from the ECMWF global spectral model (cycle 34) and adapted to local needs. The resolution is T106 (triangular truncation at wavenumber 106) with a Gaussian grid of 320*160 points and a quasi-regular mesh size of ~ 1.125°. In the vertical, 19 layers are used.

The regional model EM covers the North Atlantic and Europe with a mesh size of 55 km in a rotated latitude-longitude grid. Since the task of the model is the production of general weather forecasts for the European area, a proper simulation of near surface processes and the hydrological cycle is of main interest. Therefore about 6 of the 20 model layers are placed in the atmospheric boundary layer.

The high-resolution DM covers central and western Europe with a mesh size of 14 km (Fig. 1) and 30 vertical layers. It allows detailed weather forecasts since it describes the modification of the synoptic-scale flow by the high- resolution topography like the highlands and mountains in Central Europe. Moreover, the DM is able to resolve fronts and convergence lines in great detail. The model results form the basis of quite a number of operational products like meteographs which graphically depict the weather forecast at arbitrary gridpoints or animated clouds and precipitation for TV. The most important use of the DM data is in environmental applications like trajectory calculations, complex dispersion models in case of nuclear or chemical accidents, sea state models, hydrological forecasts or the prediction of road condition.

A workstation version of EM/DM is available to other national meteorological services, universities and research institutions, see Tab. 2 for the current users. Several countries like Brazil, Israel and Rumania started quasi- operational forecasts of EM/DM for their region of interest based on analyses and forecasts out to 84 hours of the GM which are written to the ftp-server of the DWD (ftp.dwd.de) twice daily.

The Model Chain of the DWD
- Current System -

Table 1 NWP System of the DWD

Topic	GM	EM	DM
Area	global	North Atlantic Europe	Central Europe
Resolution	T106 ~200 km	0.5° ~55 km	0.125° ~14 km
Layers	19	20	30
4-d data assimilation	$\Delta t = 6$ h, OI, NMI first guess: 6-h forecast		
Forecast range	00 UTC 168 h 12 UTC 168 h 18 UTC 48 h	00 UTC 78 h 12 UTC 78 h 18 UTC 48 h	00 UTC 48 h 12 UTC 48 h 18 UTC 48 h
Flop / gridpoint, layer, timestep	3400 $\Delta t_{RAD} = 3$ h	3400 $\Delta t_{RAD} = 2$ h	5000 $\Delta t_{RAD} = 1$ h
CPU-time for 24-h on CRAY-C98	1100 s	1400 s	5200 s

Figure 1 Model domain of the Deutschland-Modell

Table 2 Current users of the models EM and DM

CRAY VERSION
• Max-Planck-Institute Hamburg, Germany, Prof. Bengtsson
• Potsdam Institute for Climate Impact Studies (PIK), Germany, Dr. Böhm
• ETH Zürich, Switzerland, Prof. Schär and Prof. Davies
• Swiss Meteorological Institute (SMI), Dr. Quiby
• Research Centre Geesthacht (GKSS), Germany, Prof. Raschke
WORKSTATION VERSION
NATIONAL WEATHER SERVICES
• Instituto Nacional de Meteorologia, Brazil, A. C. De Athayde
• Directorate of Hydrography and Navigation, Brazil, LCDR Ricardo C. Almeida
• Scientific Research Department, El-Qoubba, Egypt, Abd ellatif Esawy Awwad
• Caribbean Meteorological Institute, Barbados, Dr. Depradine
• National Meteorological Service of Ethiopia, Dr. Haile
• Israel Meteorological Service (IMS), Dr. Seter
• Meteorological Service of Italy, ITAV, Dr. Ferri
• National Meteorological Service of Romania, Dr. Pescaru
• Swiss Meteorological Institute (SMI), Dr. Quiby
• National Meteorological Service of Bulgaria, Dr. Syrakov
• Guangzhou Regional Meteorological Centre, China, Prof. Ji-Shan Xue
UNIVERSITIES
• MPI Hamburg, Germany, Prof. Bengtsson
• University of Karlsruhe (TH), Germany, Prof. Dr. Fiedler
• University of Vienna, Austria, Prof. Hantel, Prof. Steinacker
• University of Frankfurt, Germany, Prof. Herbert
• University of Bonn, Germany, Prof. Kraus
• University of Nairobi, Kenia, Dr. Mukabana
• Department of Atmospheric & Oceanic Science, India, Dr. Murthy
• IPMET/UNESP, Brazil, Prof. Neto
• University of Ljubljana, Slovenia, Prof. Rakovec
• Research Centre Geesthacht (GKSS), Germany, Prof. Raschke
• Marine Institute of Kiel, Kiel, Germany, Prof. Dr. Ruprecht
• ETH Zürich, Switzerland, Prof. Dr. Schär
• University of Bern, Geographical Institute, Switzerland, Dr. Schuepbach
• DLR-Institut für Physik der Atmosphäre, Germany, Prof. Dr. Schumann
• Academy of Sciences of Czech Republic, Dr. Stekl
• University of Leipzig, Germany, Prof. Tetzlaff, Dr. Mölders

NUMERICAL WEATHER PREDICTION AT THE DEUTSCHER WETTERDIENST (DWD)

- FUTURE SYSTEM -

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ABSTRACT

The development of the next generation numerical weather prediction (NWP) system at DWD was motivated by the demand for accurate, local-scale weather forecasts and a need for a reduction in system complexity. Also, the design had to account for distributed memory parallel computers as future platforms. Therefore, it was decided to base the new system on two models (Tab. 1): the global gridpoint model (GME) and the very high resolution (2.5 km) regional nonhydrostatic Lokal-Modell (LM).

GME is based on the hexagonal triangular grid derived from an icosahedron (Fig. 1) and the operators defined by Baumgardner (Los Alamos Nt. Lab., USA). The hexagonal grid makes possible a quasi-uniform mesh size over the globe with a variation of less than 20%, and it avoids the pole problem of traditional gridpoint models in geographical coordinates. The gridpoint approach supports good scalability on distributed memory massively parallel computers (MPP systems) due to the local stencils. Moreover, at higher horizontal resolutions the method is more efficient than the spectral one as it scales quadratically with resolution contrary to the cubic dependency of spectral models. The Helmholtz equations of the semi-implicit scheme of GME are efficiently solved by a multigrid method. A close cooperation exists with the GMD (Forschungszentrum Informationstechnik, Birlinghoven, Germany) regarding numerical methods and code parallelization. Physical parameterizations are mostly updated versions of the schemes of the Europa-Modell (EM) of the DWD which have proven their reliability in operational forecasting since several years. The inclusion of subgrid-scale orographic effects is based on modules developed at ECMWF (UK). First systematic evaluations of the GME in short range forecasts and climate mode indicate that the model is capable of simulating many features of the observed atmosphere properly. A fine-tuning of the model parameterizations is still necessary as well as improvements in the numerics and parallelization of the program.

LM is the regional component of the new NWP system. It is non-hydrostatic and uses the elastic equations of motion. Due to the complexity of such models LM is organized as an international cooperative project to broaden the basis of expertise. A number of research institutes and universities, as well as the Swiss Meteorological Institute are currently taking part in the development of LM. On the international level, DWD is the Lead Centre for Non-hydrostatic Modelling within SRNWP (Short Range Numerical Weather Prediction) of EUMETNET (European Network of Meteorological Services). The prognostic variables of LM are the three velocity components u, v, w, temperature T, and the three-dimensional pressure deviation $p' = p - p_o(z)$, and the specific water vapour q_v and cloud water q_c contents. The reference pressure $p_o(z)$ has been introduced only to reduce the truncation error associated with orography. The dynamic part of LM was designed following the description of the model MM5 (Penn State/NCAR Mesoscale Model). LM uses the Arakawa C-grid and a split explicit method where the fast gravitational and sound waves are treated by a smaller time step than the advection processes. Since the main application of LM is the production of detailed weather forecasts up to 48 hours, main emphasis is placed on the proper parameterization of near surface processes and the hydrological cycle. A sophisticated land surface parameterization scheme including vegetation derived from a SVAT (soil vegetation atmosphere transfer) model developed at the agrometeorological branch of the DWD will allow an accurate simulation of near surface fluxes of heat and moisture. A prognostic equation of the turbulent kinetic energy enables a better diurnal evolution of the atmospheric boundary layer than currently possible with a diagnostic scheme for the computation of the turbulent exchange coefficients. Further developments include prognostic equations for cloud ice and precipitation phases. The model has been coded in FORTRAN 90 and parallelized for MPP systems using the message passing interface

(MPI). First tests of LM with a 2.5-km grid indicate that the model is able to resolve deep convection explicitly (Fig. 2). Thus the life cycle of convective cells can be forecasted in greater detail compared to current models which parameterize convection.

The initial state of GME will be derived by an intermittent 4-dimensional data assimilation scheme based on optimal interpolation. For LM, a nudging technique allows to extract more information of observing systems with high temporal resolution (e.g. wind profiler, SYNOP stations).

A first pre-operational parallel trial between the current operational system (GM, EM, DM) and the new one (GME, LM) is scheduled for spring 1998.

Model	Type	Resolution		Domain	Lateral Boundary
		horiz.	vert.		
Global-Modell (GME)	hydrostatic grid: triangular semi-Lagr., semi-implicit	ni=256 ~28 km	40 lay.	global	-
Lokal-Modell (LM)	nonhydrostatic grid: λ', φ' hor.: split-expl. vert.: implicit	0.025° ~ 2.5 km	50 lay.	Germany/ surrounding	GME Δt_{LB}=.5h

Model	Initial State	Start (UTC)	Forecast length (h)	Flop/ 24 h
Global-Modell (GME)	intermittent data assimilation, 6-h cycle, OI, digital filtering	00 06 12 18	168 48 168 48	300 10^{12}
Lokal-Modell (LM)	continuous data assimilation, nudging	00 06 12 18	48 48 48 48	300 10^{12}

Table 1 Fourth NWP System of the Deutscher Wetterdienst (planned for 2001)

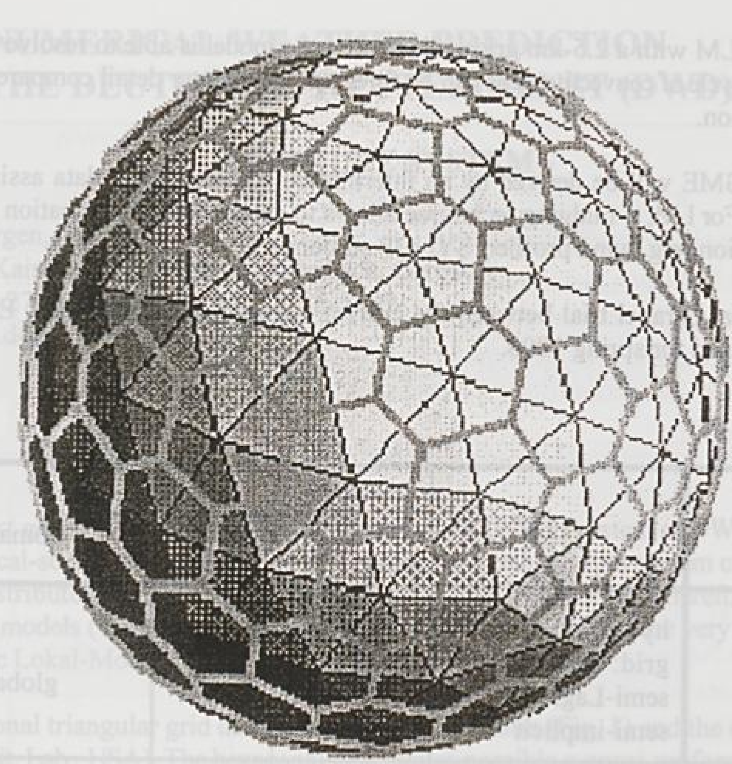

Fig. 1 Hexagonal triangular grid of the GME. (after Heikes and Randall, Colorado, USA)

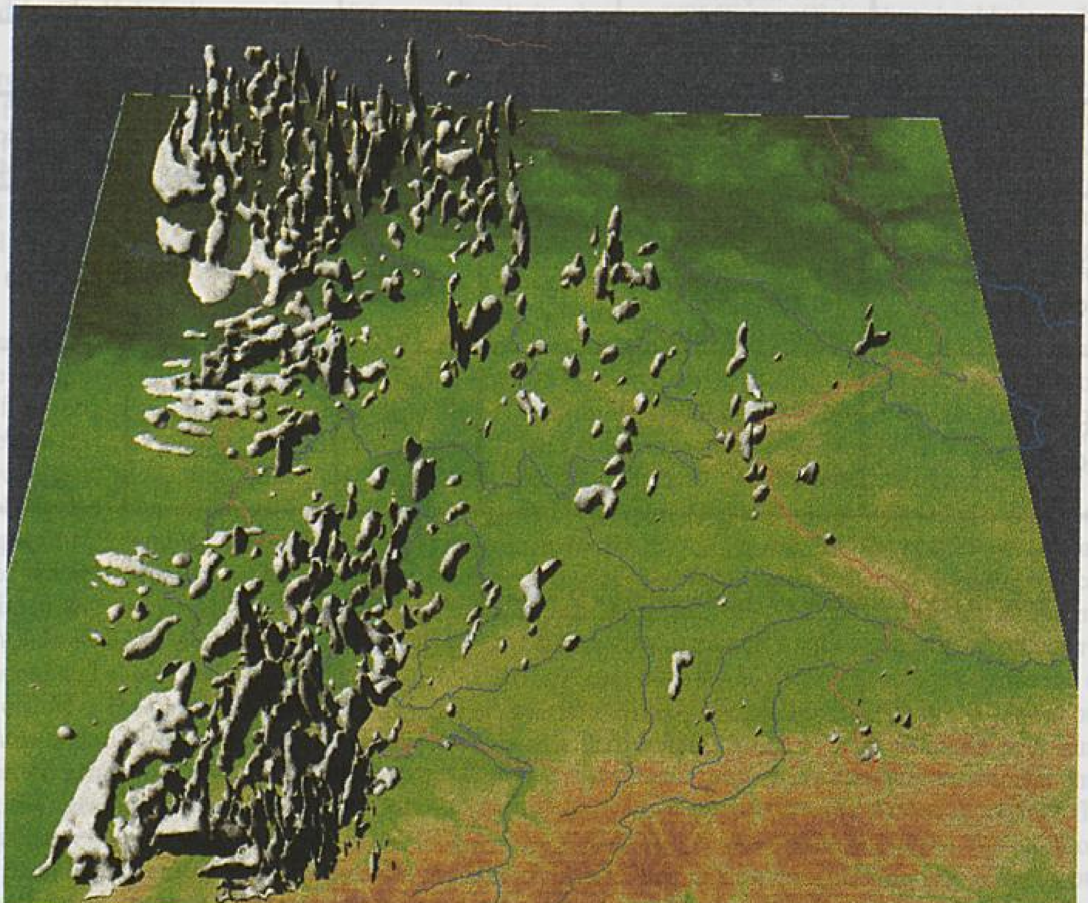

Fig. 2 12-h LM forecast of convective clouds in southernwestern Germany

Temporal Developments of Convective Cells in Radar Observations

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Introduction

Single cells, multicells and convective systems influence transport, business and industrial facilities in a period of changing climate. The general need for warning messages and storm forecasts increases despite an insufficient understanding of all cell interactions. A variety of storm mechanisms have to be understood and regarded particularly in the operational environment. For storm detection more customers request graphical radar information for own special purposes without further meteorological interpretation.

1. Radar detection of convective cells

Hohenpeissenberg radar and 13 operational radars of the German Radar Network ("RADARVERBUND") provide a spatial and temporal resolution of cell reflectivity of 1km³ (1°/1km) and 5 and 15 min, respectively. Here, the radar reflectivity Z represents the essential information of the storm structure and its rain shafts and echo cores. The development of high reflectivity, indicative to large droplets or hail, as well as the horizontal (and vertical) extension and echo change are characteristic of cell type and stage.

Under certain wind shear conditions single cell or multicell growth can be observed leading to the NOWCASTING requirement of cell tracking and position and stage forecast e. g. as supercell development, regenerating multicell system or squall line formation.

2. Concept of cell analysis

The basic principles for a tracking program (CONRAD: CONvective cells in RADar) were defined as: detection of the echo pattern change in 5 min steps in the 100 km radar range, reduction to low level cell structure, "appearance" and extent of 55 dBZ cores and definiton of warning thresholds. The very short time intervals provide a maximum knowledge and interpretation of structure change.

Another agreement was the concentration on only core-developing cells (>46 dBZ=>20 mm/h) and their tracking, represented by symbol graphics rather than radar reflectivities.

Primarily only the base reflectivity of the operational PX radar image (200x200 km²) is used to locate each 46 dBZ cell core which is assigned to a cell code (capital letter) and time code. The growing or shrinking cell centroid as well as the termporary "apperarance" of a >55 dBZ inner core are expressions of the current (hydrometeor-) activity of the storm in its stage. Furthermore cell merging and deceleration by multicell processes were signs of an intensifying stage, too.

3. Cell stages, cell activity, warning messages, forecast

The 5-min cell tracking and analysis gives a good insight into the internal cell structure close to the ground. Embedded in the general propagation field, single cells or systems with deviating propagation are emphasized as well as locations of stationary high reflectivity. Core splitting is a frequent event (12% according to DIXON and WIENER, 1993). Certainly the vertical echo structure (only in 10-15 min intervals) can complete the cell stage analysis but is presently restricted to hail warnings.

As the 46 dBZ-tracking concentrates on single cells, it identifies in squall lines or convective complexes only multicell core development and cell shifts but not the complete system.

The warning symbols include a preceding hail warning reflectivity (46 dBZ in 4-5 km height) and a reflectivity of existing high hail probability (55 dBZ, yellow ▵) or some 60 dBZ message. Here a level-2-hail warning (extreme) is issued where the 55 dBZ core exceeds 10 km², which means that the locally estimated 5min-rain intensity exceeds the annual record and is thus less probable than hail.

Coupled with this is the attempt to issue also a warning for local severe rain intensity accompanying the storm centre. It has to be separated from hail-typical reflectivities, so >55 dBZ-rain rates are restricted (to 70 mm/h, or 5.8 mm/5min). A severe rain intensity warning (yellow ○) ideally represents >20mm/30min by 5 min- overlapping echoes, each lower than the 64 mm/h equivalent. It is issued on-line at the moment of maximum contribution of rain rate in the cell lifecycle and is locally assigned to a 1 km scale.

The forecast of CONRAD shows the extrapolated +10 min-position of the cell core assuming a continuous cell stage. Dissipating squall line rain has not been taken into consideration by a warning message when the >20mm rain amount is accumulated during more than 30 min (will be extended in future).

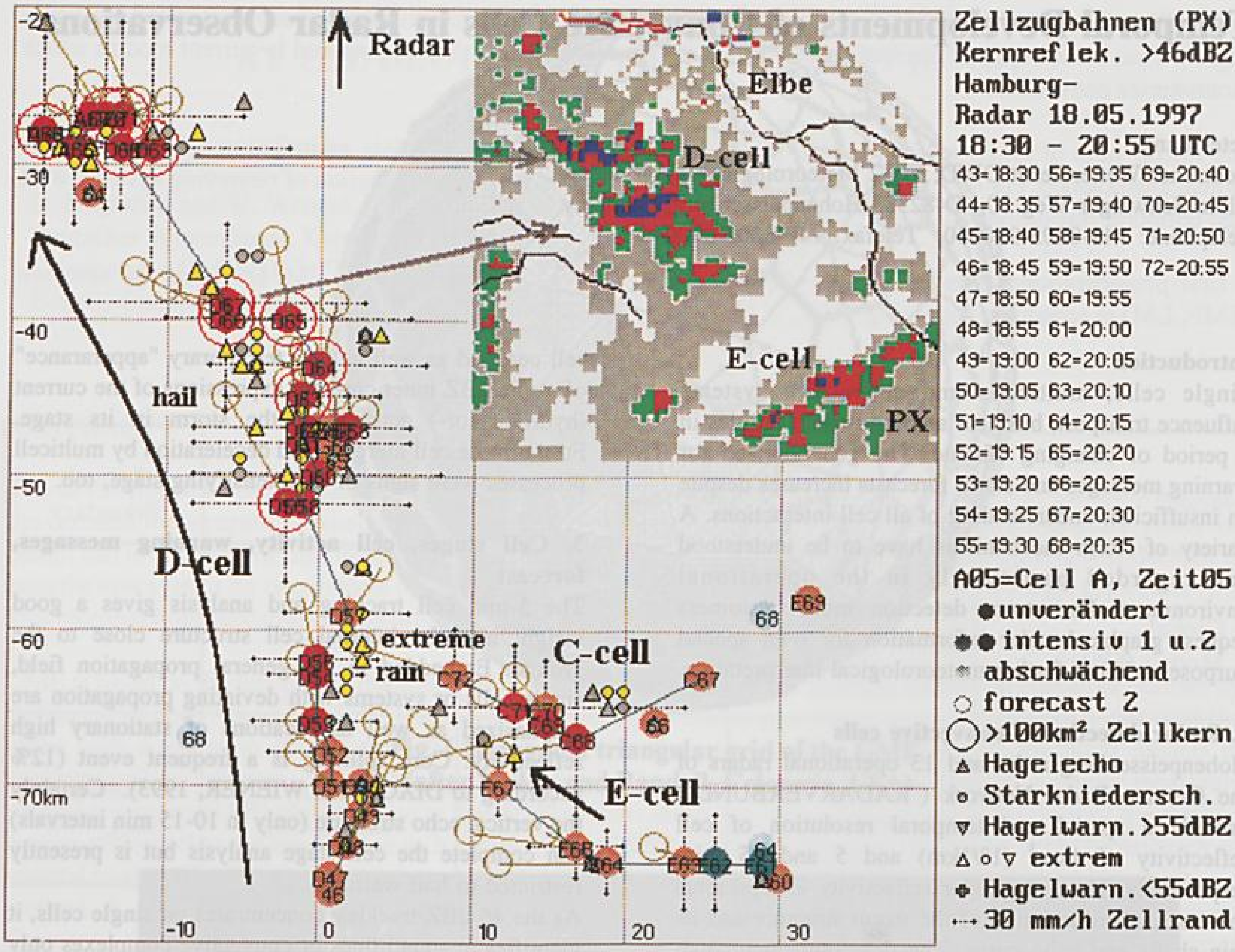

Fig. 1: Cell tracking on May 18, 1997 from 18:30-20:55 UTC in a 50x70km² area (100 km² boxes) south of Radar Hamburg. D-cell (time code 46=18:45 to 72=20:55) track northward with red cell stage (blue= new or constatnt cell stage), hail (yellow Δ) and severe rain (yellow o) symbols. Open circles represent the 10min position-forecast and circles around cell code mean cell cores >100 km². +----+ marks the real span of the cell core (>30 mm/h). The insertion shows the PX reflectivities at 20:30 (time code 67) with cells C,D and E. Cell D is just "jumping" to the northwest by new cell generation and simultaneous decay (also 1 hour ago). Red and blue reflectivities mark >30 and >70 mm/h areas (>46 and >55 dBZ), green >6mm/h and grey-brown represents stratiform rain rates.

4. Case studies

In the test modus CONRAD is applied to 5min/200km radar image series to show the concentration and activity of cell propagation mostly off-line. The different cell tracks, sometimes again used by following cells, are as easy to analyze as each peak cell stage and the location of hail and severe rain activity. Also multicell generation in core distances of more than 10 km can be detected and collisions of smaller cells with right-moving multicells, too (intensifying stage). But CONRAD normally runs in a simulated on-line loop with the recent 30min tracks moving in the frame of the NOWCASTING area, showing in succession the actual cell position, stage, recent warnings and recent trackline. From a number of case studies first estimations of the frequency of multicell development, cell splitting and hail or severe rain events will be possible.

5. Life cycles, cell stages

The life cycle of an advanced storm starts with a selected 16 km² cell core development of >46 dBZ (>30 mm/h) and regards only dominant summer storms. In early summer 25% of these cells continue to stage "red 1" ("intensiv 1", Fig.1) with a beginning hail contribution from a small 55 dBZ (>70 mm/h) inner core. 1.5% of the originally detected cells reach cell stage "red 2" ("intensiv 2") with a broader 55 dBZ core or a dimension-movement relation producing local severe rain (forecast of local severe precipitation with 4.5 mm/3min and embedded hail). These red stages are often at immediately followed by a detected 10km² field of severe rain intensity or hail (Fig. 2) or the return to normality. This warning goal has to be better investigated and depends on sudden developments (hail shafts).

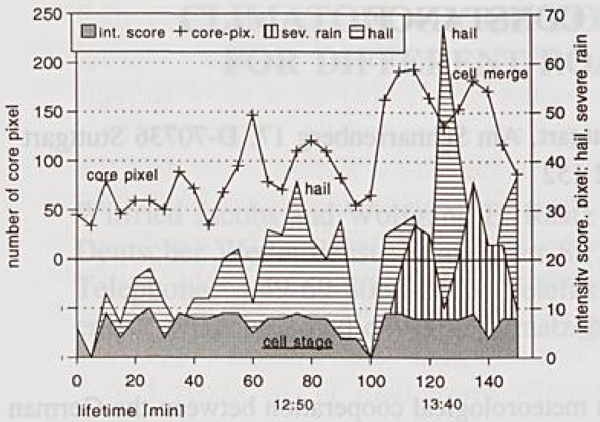

Fig. 2: Life cycle of cell A on July 22, 1995, Radar Neuhaus. Increasing cell core (1 pixel=1km³), activity (hail, severe rain) and high cell intensity score (max: 12, red 2 starts at 6) during 150 min of cell activity.

But this high echo detection is also sensitive to incorrect radar calibrations. Extreme hail echoes >60 dBZ are often accompanied by wind gusts and even microbursts (FUJITA, 1994) when cold air cores burst to the ground, so that such hail warnings also stand for gustiness.
Most of the detected cells "live" less than 1 hour with their mature stage often in the second half of their lifecycle. Multicell complexes with lifetimes of more than 1 hour develop to their mature stage often in the first half (e.g. after 15 min) with several mature stages following (Fig. 1, Cell D). Here the dissipation stage lasts longer, too. Severe conditions (hail, severe rain intensities) originate in long living complexes and appear often in the first half of the longer life cycle e. g. after 25 min.

So a forecast of each peak development is governed by the individual assumption of cell stage e.g. red 1 to grow to stage red 2 and the remaining time until real warning conditions occur (or not). This can happen within 5 to 15 min. Everything else means tracking a fully grown mature multicell accompanied by warning conditions along its track and forecasting its present stage or final decay. Until today, no clear indication has been found for a further development or downburst of extreme core reflectivity (>55 dBZ).

6. Cell activity at the ground

The need for warnings and their verification are often documented by news messages. For the urgency of 5min and 1km resoluted warnings the correct geography, topography and infrastructure of the cell-covered area and forecasted area should be known. Special overlay maps are necessary. However the general NOWCASTING benefit of such high resolutions has to be considered. Even if dominating systems are the real challenge, also smaller cells have to be detected and classified early enough. The application of cell analysis and warning conditions is estimated at <20 days per year.
Finally CONRAD cell tracking can also be used as a survey on cell track, stage and warning for selected sequences and areas after the event (e.g. for insurance companies).

7. Future developments

Tracking of cells can be made satisfactory for isolated cells like multicells or supercells. In large bow echoes or line cells the propagation of cores can be diffuse, nevertheless the hail cores and stationary rain maxima are still essential warning spots.
The forecast (10 min) of the cell position can be enhanced according to the reached lifetime (>30 min, >60min) of the cell and its stable propagation. Left- or right-moving systems can be filtered from the mean propagation of the other cells and treated as intensive (stage red 2). The stage analysis and forecast have to be further improved.
Apart from the low-level cell reflectivity the vertical structure can complete the analysis and forecast of the cell stage by its vertical echo extent, anvil growth, grow rate (Doppler radar) and overhang region, e. g. as an additional hail indicator.
The cell statistics are in the very first state, including the frequency of multicell activity, mean and extreme storm velocity, hail and severe rain frequency and splitting and merging events.

References:

DIXON, M., WIENER, G., 1993: Thunderstorm identification, tracking, analysis and nowcasting - a radar-based methodology, J. of Atm. a. Ocean. Tech., Vol. 10, No. 6, p 785-797

FUJITA, T. 1994: The mystery of severe storms, Univ. of Chicago press.

STORM WARNING SERVICE FOR LAKE CONSTANCE

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ABSTRACT

The storm warning service for Lake Constance based on meteorological cooperation between the German and Swiss Weather Services (DWD and SMA). Unlike the North Sea and Baltic Sea where warnings are given according to the mean wind velocity, the warnings for Lake Constance are issued according to gusts. There are two different warnings: the "Vorsichtsmeldung" which means that gusts over 25 knots can occur. This warning is also given in connection with local showers and thunderstorms. The "Sturmwarnung" indicates a direct danger of gusts over 25 knots which occur on at least half of the lake. Lake Constance is divided into an eastern and a western part and the division runs from Friedrichshafen to Uttwil. On the whole shore of the lake there are 43 remote-switched orange stormwarning signals. For the German shore the setting of the signals is under the responsibility of the water police force at Friedrichshafen, in Switzerland it is the task of the canton police in Thurgau and in Austria the Gendarmerie Commando Bregenz is responsible.

From the 1st of April to the 31st of October both warnings are issued between 7am and 10pm. In wintertime, 1st of November to the 31st of March, storm warnings are only given between 7am and 8pm.

CLIMATOLOGY OF ROAD-SURFACE TEMPERATURES FOR DIFFERENT ROAD SITE CHARACTERISTICS

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Presently the Deutscher Wetterdienst (DWD) issues detailed area forecasts of road conditions and of road-surface temperature as a part of the German road weather information system, called SWIS (Straßenzustands- und Wetterinformationssystem). To produce these forecasts an energy balance model (Jacobs&Raatz, 1996) is used, which is able to take into account the five different site characteristics 'regular traffic', 'little traffic', 'urban influences', 'shaded areas' and 'bridges'. However, up to now there exists no further distinction between different types of bridge construction nor due to the varying topography.

Based upon a climatology the behaviour of the three road site characteristics 'regular traffic', 'shaded areas' and 'bridges' will be discussed first. For the present study about 60 road weather monitoring stations, which are situated along German motorways, could be categorized according to these three different road site characteristics. Using the Student t-test it will be checked, if the behaviour of these road site characteristics shows significant differences from each other. In addition, a first attempt is tried, if it is useful to distinguish additional road site characteristics, which are caused by the different types of bridge construction or by the varying topography. The types of bridge construction considered are 'steel plate', 'hollow body', 'steel construction' and 'concrete construction', the different types of the topography considered are 'plain', 'forest', 'cutting' and 'crest'.

In order to eliminate the local influences on the road-surface temperature, which are not due to the different road site characteristics (e.g. influence of the altitude), only the differences between the air temperature and the road-surface temperature (TL-TS) are considered. In order to obtain representative results, which are typical for each road site characteristic (and not determined by the individual pecularities of the measuring site), averages of (TL-TS) based upon several road weather monitoring stations are calculated. In addition, it is necessary to consider particular synoptic situations, in which there are only small differences in cloudiness over a large area in order to make sure that differences observed are caused by the different road site characteristic only, and not by different radiation regimes. Two time periods, which meet that criterium, are chosen: 16 January to 21 January 1996 (dull or foggy) and 14 February to 18 February 1994 (clear sky condition).

A third time period (21 December to 25 December 1996) is selected to investigate the reaction of TS due to a sudden change of TL, because during that time period first a strong warm air advection occurred followed by a strong cold air advection. However, in this case it does not make sense to consider averages of several road weather monitoring stations because the change of air temperature occurred at different locations at different times.

The results show that especially during clear sky conditions it is necessary to distinguish between the road site characteristics 'regular traffic', 'shaded areas' and 'bridges'. During the day 'regular traffic' and 'bridges' show similar values of (TL-TS) of -4 to -6 Kelvin. During the night TS and TL do not differ much for the site characteristic 'regular traffic'. However, 'bridges' exhibits values of TS, which are by about 1 to 2 Kelvin lower than the values of TL. Considering 'regular traffic' the daily minimum- and maximum-values of TS occure about 1 hour earlier than the extremes of TL. In the case of 'bridges' the time lag of TL against TS is about 2 hours during the day and about 1 hour during the night. In the case of clear sky conditions and during the day the road site characteristic 'shaded areas' shows a total different behaviour in comparision to 'regular traffic' and 'bridges'. (TL-TS) exhibits an insignificant diurnal cycle, but TS is usually lower than TL by about 1 to 2 Kelvin.

During dull or foggy weather conditions and during the day the following differences can be observed: In the case of 'regular traffic' and 'shaded areas' TS is about 3 to 4 Kelvin higher than TL. 'Bridges' has values of TS, which are about 2 to 3 Kelvin higher than TL. For all road site characteristics it can be observed that TS is by about 1 to 2 Kelvin higher than TL. Only in the special case, when there is little traffic (e.g. on weekends), 'bridges' tends to have values of TS, which are about 0.5 to 1 Kelvin lower than TL. In the case of 'regular traffic' and 'shaded areas' the minimum- and maximum-values of TS and TL can be observed at similar times. For the site characteristic 'bridges' it can be observed that the extreme values of TS occure by about 1 hour earlier than the extreme values of TL.

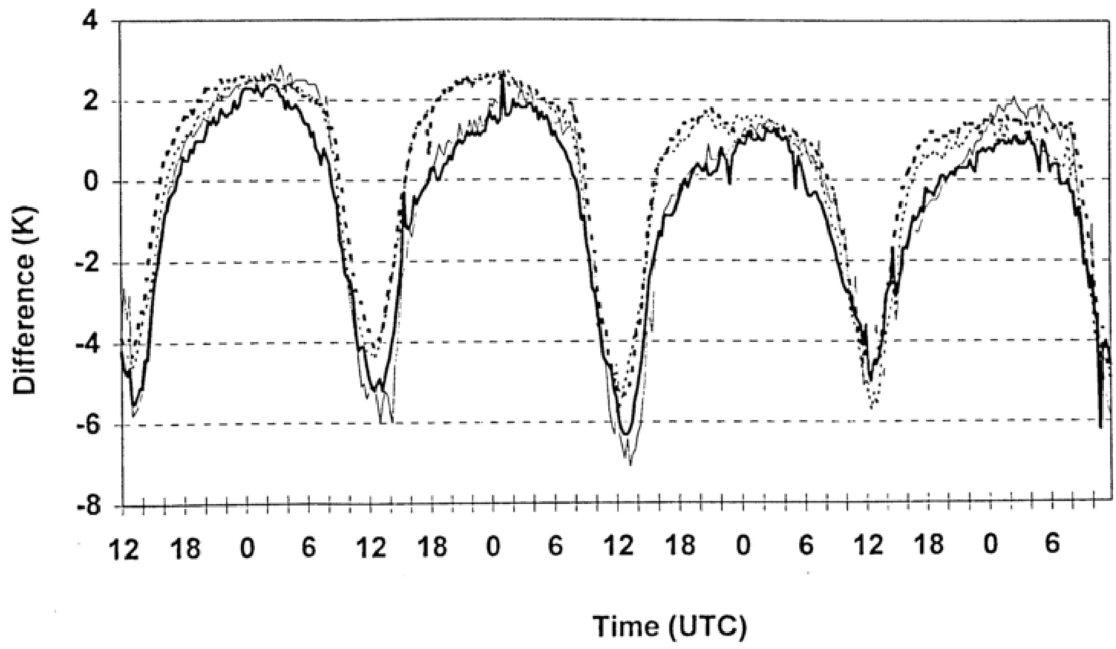
The road site characteristics, which are defined by the topography ('plain', 'forest', 'cutting' and 'crest'), exhibit only a few significant differences between their mean values of (TL-TS) both during dull or foggy weather and during clear sky conditions.

However, for the different types of bridge construction significant differences can be observed during clear sky conditions and during the time period from the afternoon to midnight. From the figure it can be seen that during the first half of the night the values of TS of 'steel construction' and 'steel plate' are relatively low in comparision to 'hollow body' and 'concrete construction'. In addition, there exists a tendency that 'hollow body' and 'concrete construction' have a larger inertia with respect to changes of the air temperature than 'steel construction' and 'steel plate'. However, the mean values of (TL-TS) of each type of bridge construction do not exceed 2 Kelvin.

During the time period between 21 December and 25 December 1996 it can be observed that while TL was increasing the increase of TS was rather similar for every type of bridge construction and of varying topography. The increase of TS occures with no noticeable delay compared to the increase of TL. During the decrease of TL, however, a delay of TS can be observed, which amounts to 0 to 2 hours for 'bridges' and to 2 to 4 hours for 'regular traffic'. Only 'concrete construction' and 'hollow body' have a larger inertia than 'steel construction' and 'steel plate'.

From this study it could be concluded that it might be useful to define in addition to the road site characteristics 'regular traffic', 'little traffic', 'shaded areas', 'urban influences' and 'bridges' the following road site characteristics 'steel construction/steel plate' and 'concrete construction/hollow body'. However, it should be pointed out that the mean differences (TL-TS) between the "old" type 'bridges', which is currently used by the DWD, and the proposed new types 'steel construction/steel plate' and 'concrete construction/hollow body' do not exceed 1 Kelvin. It seems unlikely that this rather small difference can be worked out by the operational forecast.

The capability of forecasting road-surface temperatures depends to a large extent on the capability of predicting correctly the synoptic input data for an energy balance model, e.g. cloudiness is difficult to predict. Thus, only improving the qualitiy of the energy balance model by considering details, which improve the results by only 1 Kelvin at most, might not be useful for routine purposes.



Time series of mean difference (TL - TS) for different types of bridge construction during the time period from 14 February to 18 February 1994 (clear sky conditions)

- - - 'concrete construction' ——— 'steel construction'

...... 'hollow body' ——— 'steel plate'

Jacobs, W. & Raatz, W.E. (1996). Forecasting road-surface temperatures for different site characteristics. Meteorol. Appl. 3, 243-256

PROVISION OF MEDIA, PRESS AGENCIES AND THE PUBLIC WITH DATA, PRODUCTS AND PRESENTATIONS

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ABSTRACT

The reorganisation and modernisation of DEUTSCHER WETTERDIENST (DWD) has been completed in 1996. The goals and missions of the reorganisation were:

- To meet the needs of the general public and the community by the provision of comprehensive weather data and weather related services with special emphasis on public safety and welfare;
- To boost the public understanding of the capabilites of the DWD;
- To reduce costs to the taxpayer

The concept of the new structure of the DWD included the founding of a Division MEDIA to facilitate a better provision, care and service for the public media including newspapers, broadcasting-stations, TV-stations and press agencies.

The new structure of the Division MEDIA meets the needs of our customers. Central and regional sales, marketing and production centers offer a broad spectrum of services at different levels (see Figure 1)

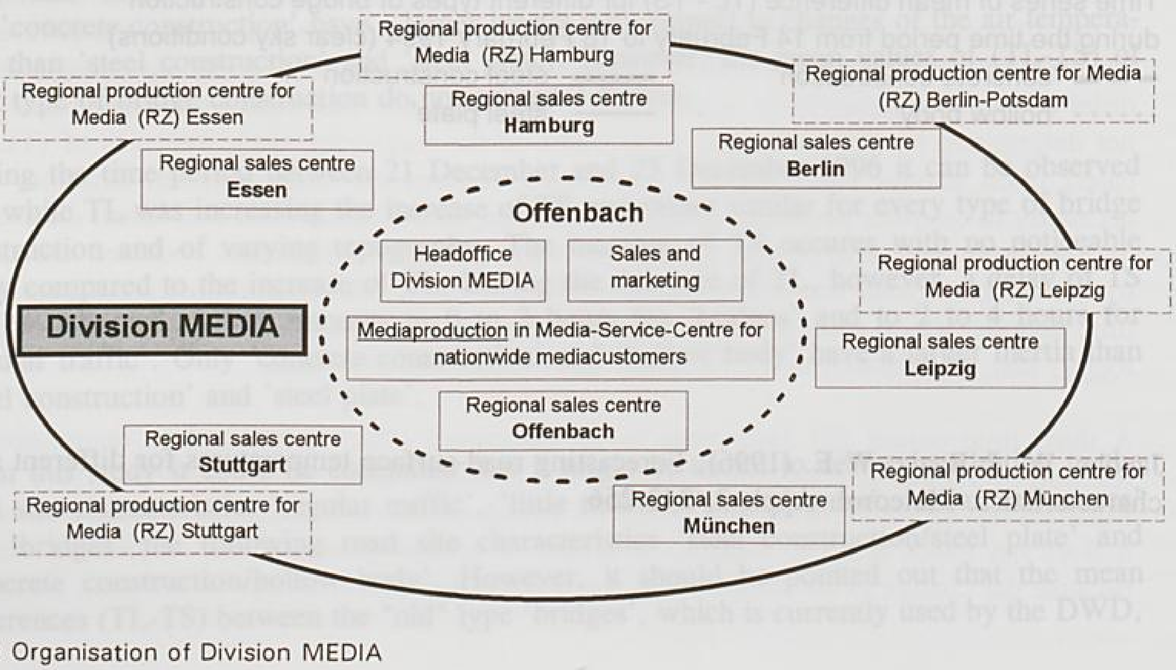

Fig.1: Organisation of Division MEDIA

The demands to the DWD by the general public and by the media have been growing remarkably fast during the past few years. A typical feature of the media sector is the increasing number of private companies and broadcasting stations. The great number of regional and subregional newspapers, broadcasting and TV stations needs a continuous provision by the DWD with warnings, observational data, forecasts in textform, regional and local forecasts and special graphical products.

The general public and other customers more and more demand custom-made products and services, forecasts with higher resolution in time and space and forecast values of specific parameters such as temperature, dewpoint, precipitation and wind instead of forecasts in general phrases. The issue of weather warnings in time and tailored to customer's needs plays an increasingly important role. To comply with these requirements and to improve the service for the public, the DWD now offers an operational nowcasting service and special medium range weather forecasts.

The provision of the general public and of public media is based on observational data, on the model chain of the DWD (Global, European and German Model) and on special post-processing techniques such as Kalman-Filtering and Model Output Statistics (MOS). The presentation and dissemination of large data volume in a custom-specific way requires powerful distribution and presentation systems. Especially for print media the DWD has developed a system to produce ready-to-print weather charts (see Figure 2).

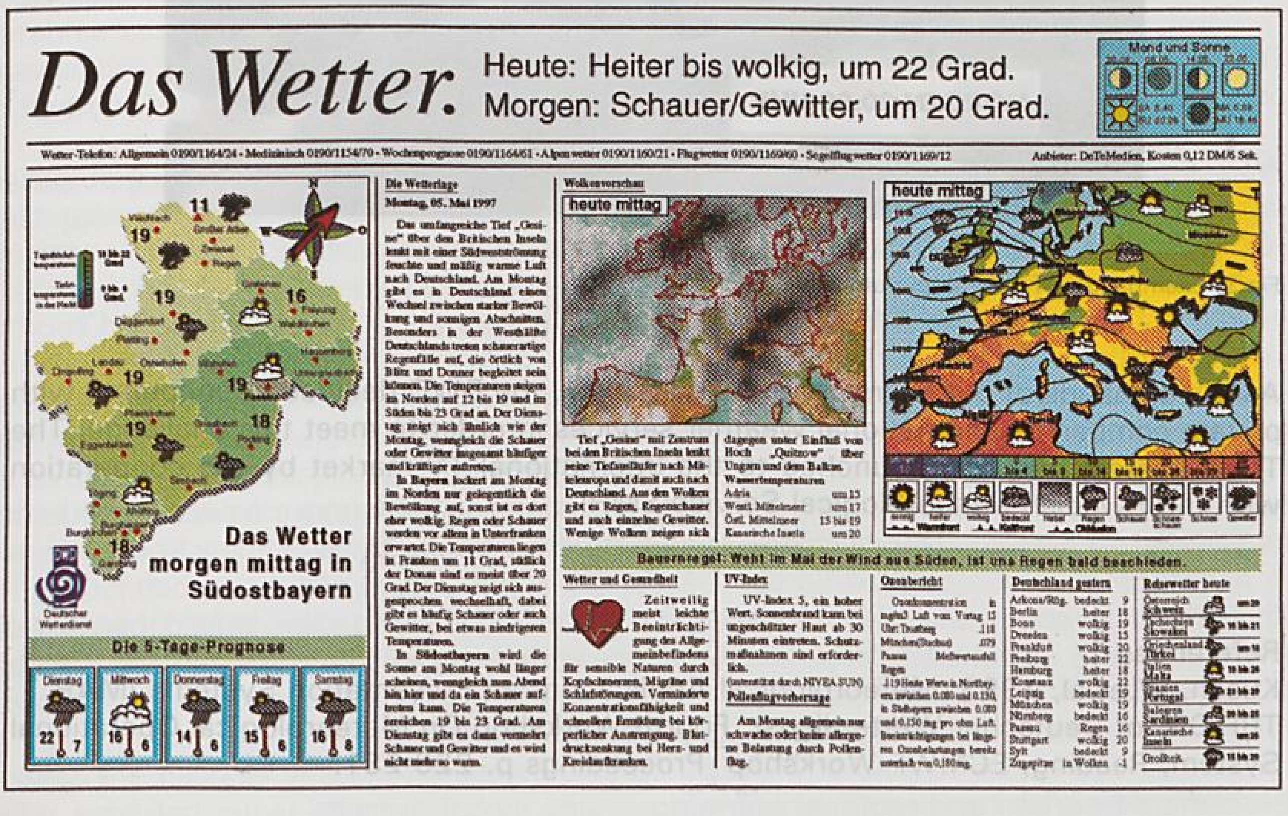

Fig.2: Example of a ready-print weather chart

The weather forecasts play an important role in daily TV-news so the DWD developed a special TV-presentation System called TriVis (3-d visualization). TriVis shows forecast clouds in a way as if seen from the ground. High level clouds appear transparent, cumulus clouds are fluffy and deep clouds like thunderstorms are dark. Moreover, our customers asked for complete systems with animated forcasts of scalar variables, pictograms and texts at specific places to be able to produce a complete weather animation show by themselves. Both systems now fulfill these requirements to the satisfaction of our customers (see Figure 3).

Fig.3: Example of a TriVis-3d-picture

As the demands of our users are growing rapidly, the DWD decided to cooperate with private companies and national weather services in order to meet this challenge. The TriVis-system has been launched to the international TV-market by the cooperation with the Swedish Meteorological Service SMHI.

References

Kusch, W.et.al, 1993: Meteorological Application- an Presentation Systems (MAP, TRITON) of Deutscher Wetterdienst. Fourth Workshop On Meteorological Operational System, Reading, ECMWF Workshop Proceedings p. 223-231.

WMO, 1996: Guide To Public Weather Services Practices, WMO-No.834.

DETERMINATION AND FORECAST OF MELTWATER RELEASE FROM THE SNOW COVER (SNOW-D)

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ABSTRACT

The poster presents results of comparisons between simulated and measured data of the water equivalent of snow cover with the aim to test, first of all, the reliability of the simulated values, i.e. to see whether the simulation model is suitable for operational purposes (forecast of water release of melting snow cover) in future.
The investigations are based on a model simulating the development of the snow cover for grid points.
A case study was performed with the data of the winter period 1994/95 in Germany.
The result proved good agreement between measured values and simulated ones as well in the mountainous regions as in the lowlands of Germany. The reliability of the simulated values and the applicability of the model for operational purposes (forecast of meltwater release) is demonstrated.
In future routine operation, the simulated data may be adapted to numerous applications. At first they will serve as input for hydrological models aiming to improve short-term flood forecasting. Moreover, the results may also provide a basis for decision-aids or analytical tools in form of diagrams or maps with regard to the demand of the user.

SERVICES IN THE WEATHER/CLIMATE AND HUMAN HEALTH FIELD

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ABSTRACT

Human biometeorology is based on the fact that atmosphere forms part of the environment to which the human organism is perpetually forced to come to terms with, in order to remain in good health, for the well-being and performance. There are three focal points: the complex conditions of heat exchange, the radiative conditions, esp. in the visible and UV-range, and potentially harmful components in ambient air of anthropogenic or natural origin. Possible services are based on the specific adaption, i.e. upgrading of synoptical and climatological products to meet the needs of the users.

In the short term field (weather) the following products are available in order to help people to handle atmospheric loads:

- Medical Meteorological Information Service
- Watch/Warning Systems
- Pollen Information Service
- UV-Information Service
- Forecast of Perceived Temperature (heat load, cold stress).

The advisory service is distributed via the telecom information service, TV, radio, and newspapers.

Products in the long term field (climate) predominantly serve for different planning purposes:

- UBIKLIM (Urban Bioclimate Model)
- Bioclimate maps (meso-scale) for e.g. regional planning
- Air Quality Management
- Health Resort Climatology

The products and services listed above make clear that human biometeorology possesses numerous tools to meet the needs of the users. The general aim is always to avoid or at least to minimize unfavourable effects, to take advantage of welfare effects, and to improve the quality of life of the general public. This will support national economic as well as individual benefits and will improve the cost/benefit relation of the NMHSs.

The following discourse focusses on products in the long term, i.e. climate field, because the short term products which are specific human health related weather forecasts are discribed in detail in another paper: "Jendritzky et al.: Use of Biometeorological Knowledge and Procedures in Services of NMSs" in this issue.

Bioclimate in urban and regional planning

Urban climate represents an expressive example of a man-made climate change that is susceptible, and therefore has early to be considered in urban planning. The subject of urban development is the maintenance or even the improvement of the climatic conditions directed to a healthy environment.

In particular the following features are of interest:

- Which type of urban structures tend to be bioclimatologically stressful?
- How can development plans be optimized?
- Which arguments can be deduced for defining development regulations?
- Which areas are appropriate for new development?
- Which areas are given priority?

The model UBIKLIM (Urbanes Bioklimamodell) was developed to provide the answers to these questions. It enables a bioclimatological assessment of climate information. The following input data are required to run the model:
- the digital height with a resolution of 10 m
- data of land use resp. urban structure (given by building height, building density, pavement, trees, etc.).

UBIKLIM calculates the fields of air temperature, humidity, wind velocity, and short- and long-wave radiation fluxes in the urban canopy layer on a summer day with fair weather conditions. These meteorological fields determine the heat exchange conditions of the human being and thus can be analyzed with the help of the Klima-Michel-model in physiologically significant terms.

The result in bioclimate maps are a scale of 1:25 000, resp. 1:10.000, appropriate for a sustainable climate-related planning in urban environments. The target is to create and guarantee healthy conditions for life and work.

Air hygiene and pollution control

Besides national standards for air quality, special air quality regulations exist in Germany for health resorts. The goal is to prevent not only adverse effects on human health but to provide sufficient air quality for medical treatment and recovery. For this task special methods for air pollution monitoring have been developed by the Deutscher Wetterdienst. Integrated sampling methods have been proved to be an appropriate technique and are in practical operation in German health resorts. These methods are characterized by their low cost and easy use. Samples can be sent to a central laboratory for analysis by mail. It is only here that analytical equipment and technical staff have to be provided.

Further application for integrated methods was found by the Deutscher Wetterdienst in an epidemiological study to measure indoor and outdoor concentration of nitrogen dioxide (NO_2) and suspended particulate matter. For 2 1/2 years these air pollutants were measured in a dense network of 30 sites in the city of Freiburg and its surrounding areas. Integrated sampling was chosen due to the high acceptance of the small and noiseless devices even in private residences. It was found that indoor NO_2 concentration on average amounts to only 55% of the mean outdoor level. In kitchens with gas cooking, however, the NO_2 mean occasionally exceeds the national ambient air standard of 80 $\mu g/m^3$. The data of suspended particulate matter exhibited rather effective indoor sources too. Below 10 µm particle diameter indoor particle concentration exceeded the outdoor level by about 5%.

The successful application of the integrated sampling technique gave rise to air quality studies in San Miguel de Tucuman and Mendoza, NW-Argentina. As a typical example of rapidly growing cities in the developing countries, these cities suffer both from industrial emissions and high traffic exhausts especially from diesel-powered buses and trucks.

The measuring campaign in Tucuman and surroundings revealed a high natural dust load due to high wind erosion of deforested soil. Considerable air quality problems are indicated by enhanced black carbon levels originating from car traffic. Additionally biomass and waste burning was found to be an important source for black carbon particles. Owing to the lack of residential heating, the NO_2-concentration exclusively reflects the high impact of traffic emissions. A pronounced annual cycle can be explained by an accumulation of air pollutants in winter months due to reduced diffusion conditions.

CONCLUSION

The benefits of climatological information are usually not realized before their application. The selected examples clearly demonstrate that human biometeorology offers numerous tools to meet the needs of the users. The general aim always is to avoid or at least to minimize unfavourable effects, to take advantage of welfare effects, and to improve the quality of life of the general public. Thus the services presented for health and increasing wellbeing are those that can be expected from the activities of NMHSs. This will lead to national economic as well as to individual benefits and will improve the cost/benefit relation of the NMHSs.

REFERENCES

Endlicher, W. and Schultz, E., 1992. An investigation of local climatology and air pollution in Tucuman (NW-Argentina). Ann. Met. 28, 34-36

Jendritzky, G., Grätz, A., Schultz, E., Endlicher, W., 1994. Urban Bioclimatology. Proceedings of the Technical Conference on Tropical Urban Climates, March 28 - April 2, 1993, Dhaka, Bangladesh, WMO, Geneva, WCASP-30, WMO/TD-No.647, 245-264

Jendritzky, G., Bucher, K., Grätz, A., Schultz, E., Staiger, H., 1994. Routine Services of the Deutscher Wetterdienst in the Weather/Climate and Human Health Field. In: Conference on the Economic Benefits of Meteorological and Hydrological Services 19-13 Sept. 1994. Geneva, WMO/TD-No.630, 265-268

Jendritzky, G., 1995. Urban ecological assessment procedures for urban areas in European climates based on MUKLIMO and UBIKLIM. Prospects for climate-oriented planning in European cities. European Academy of the Urban Environment, Berlin, 34-37

Jendritzky, G. and Kalkstein, L. 1997. Climate Services to the Health Sector. WMO-Bulletin Vol. 46, No. 1., 30-32

Schultz, E. and Staiger, H., 1989. Personal exposure to indoor and outdoor air pollution. In: Man and his Ecosystem (L.J. Brasser and W.C. Mulder, eds.) Elsevier Science Publishers B.V. Amsterdam, NL, Proceed. 8th World Clean Air Congress, Vol. 3, 7-12

THE USE OF THE LEAF-WETNESS DURATION IN THE ROUTINE AGROMETEOROLOGICAL ADVISORY SERVICE OF THE DEUTSCHER WETTERDIENST

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ABSTRACT

An overview is given of the calculation of leaf-wetness duration, its inclusion in phytopathological models to forecast the outbreak and evolution of plant diseases, and on the information links to farmers.

INTRODUCTION

It is commonly known that weather plays a key role in plant epidemiology. In particular, leaf-surface wetness produced by dew, fog or precipitation is one of the most significant meteorological pest-promoting factors that trigger fungal and bacterial plant diseases and activities of insects, and that influence the effectiveness of pesticides and the uptake mechanism for gases deposited onto vegetation. Many phytopathological models use the leaf-wetness parameter in combination with other factors in order to assess the infection risk and pest severity, and to manage disease control activities in an efficient way.

One of the objectives of the Deutscher Wetterdienst is to analyze the leaf-wetness risk potential of the weather and to forecast agricultural pests and diseases dependent on leaf wetness. In order to assess the daily state of these risks, the Deutscher Wetterdienst runs the so-called AMBER software (AMBER = AgrarMeteorologisches BERatungsprogramm = agrometeorological advisory programme) which produces a broad spectrum of agrometeorological outputs for the current day and four subsequent days. Through its agrometeorological advisory service the Deutscher Wetterdienst (DWD) supports the farmers' control programmes by means of early warnings based on AMBER results.

METHODS AND PROBLEMS IN IDENTIFYING LEAF-WETNESS PERIODS

In Germany, farmers can also obtain additional information on plant cultivation and pest management from local advisory services or special plant protection services using dense mesoscale agrometeorological networks. These networks are often equipped with non-standardized wetness sensors with various designs and sensitivities. For example, some devices operate mechanically based on the humidity-dependent elongation of a hemp string making analogue traces on a clock-driven chart, while other devices electronically measure the wetness-induced conductivity change of a water-absorbant paper or of a leaf surface fixed between two electrodes. Capacitive elements work according to a similar principle. It is very difficult to compare the results of the different sensors because the heat balance, accuracy and sensitivity may change significantly from one system to another and because calibration can only be done in a subjective manner. In contrast to these measurements, the DWD makes use of microclimatic models for leaf-wetness calculation. These are supplied with data from the DWD's standard weather observation network, from the weather forecast model and, tentatively, from the weather radar.

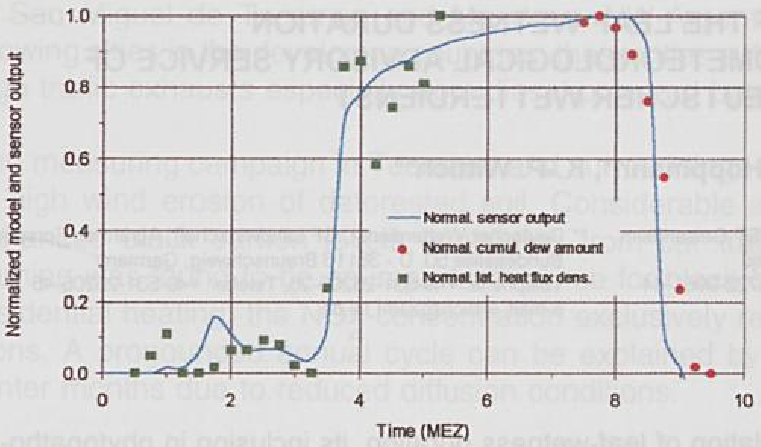

Fig.1: Simulation of a capacitive sensor response (continuous line) with a leaf-wetness model (circles and boxes) for a dew night (experimental site at Dossenheim, 1 Oct. 1992)

LEAF-WETNESS CALCULATION SCHEMES

The calculation schemes of leaf wetness distinguish between low crops, for example potato or wheat crops, and canopies with foliage-free bottom such as apple orchards and vineyards. In low crops leaf-wetness duration is modelled in a complex manner using a multi-layer SVAT scheme (Braden, 1995). Crop-dependent radiative transfer, soil moisture and the flow regime affect the crop microclimate and, together with rain and dew water interception, the leaf-wetness duration. In contrast to this, for orchards it is assumed that the soil has no effect on the leaf-wetness duration. The calculation scheme is restricted to more simple energy balance principles and to the engineering heat transfer theory, so that the leaf-wetness modelling is much easier. Only the top leaf of an orchard is regarded, which can form and evaporate dew under the influence of a laminar flow and forced convection. Leaf-wetness duration due to rain is given by the duration of the rain period itself and, during the following rainless hours, by the lifetime of a water drop settled on a leaf.

Fig. 1 shows a dew simulation at the top of an apple orchard using air temperature, relative humidity and wind speed measured at the canopy top, and downward directed components of atmospheric radiation. A comparison is made with the output signal of a plate-like capacitive wetness element which was also mounted on the top of the orchard, proving adequate agreement between modelling and measurement. After such model validations with 'high quality' leaf-wetness measurements made under controlled conditions, our models can be supplied with meteorological standard data of all the synoptic stations, providing results which are comparable for a whole network because of the same underlying physical principles and standards.

USE OF THE RADAR NETWORK FOR LEAF-WETNESS ESTIMATIONS

One of the disadvantages of the network of synoptic stations is the 50-km resolution, which is too coarse for special agromet. crop-surveillance tasks. Therefore, in order to obtain a higher spatial resolution of the leaf-wetness estimates, experiments are currently being carried out to use the

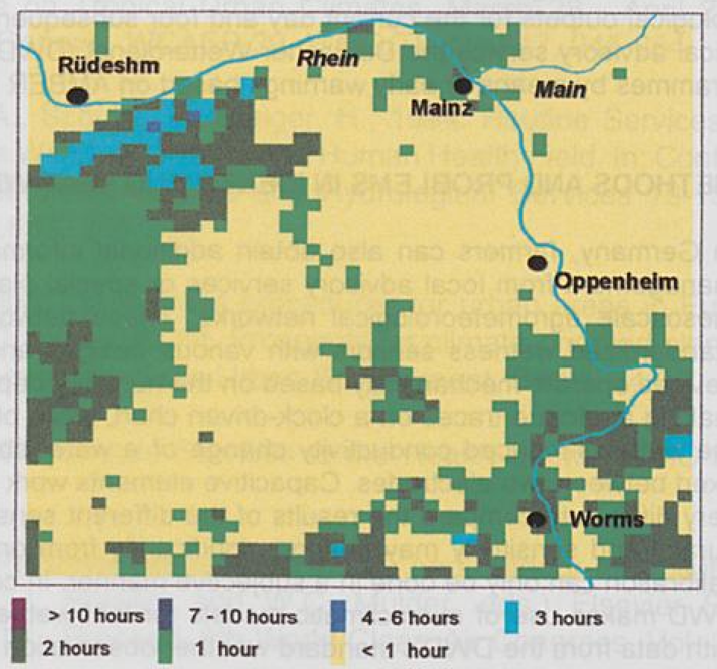

Fig. 2: Rain duration derived from weather radar output (Rheinhessen, 51*51 km) on 20th, May, 1997, 06-18 UTC

hourly radar measurements of rainfall. After defining thresholds for eliminating topography-induced errors and offsets due to other noises, a temporal accumulation of corrected binary 'yes-no' outputs of rainfall provides an image of daily rainfall duration (minimum wetness duration). Fig. 2 shows an image of this kind for a vine-growing area in Rheinhessen. The image consists of 51*51 grid cells, each one 1km*1km in dimension.

APPLICATION OF LEAF-WETNESS DURATION

The AMBER software contains a number of subprogrammes which describe the wetness-dependent behaviour of fungal plant diseases in apple orchards, vineyards, cereals, etc. Fig. 3 shows the disease potential of the *Plasmopara viticola* pathogen in vineyards. The model is supplied with measured and with simulated wetness data giving satisfactory agreement. It is assumed that economic losses do not occur as long as the number of oil-spots remains below a threshold of 5000 spots per hectare. On 8 July this critical level is exceeded, so that spray applications can be recommended.

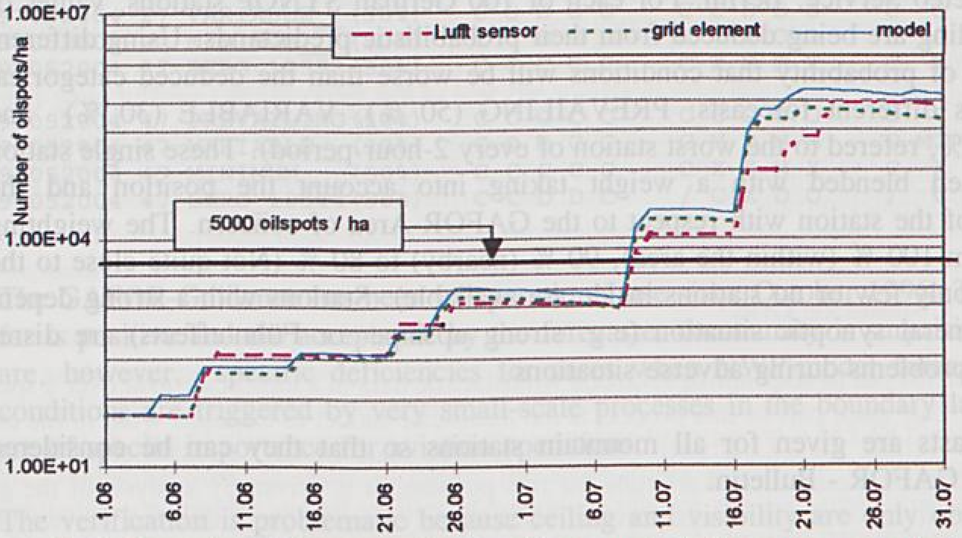

Fig. 3 : Comparison of Plasmopara viticola model runs supplied with sensor-measured and with simulated leaf-wetness data for the period May - July 1995

Other leaf-wetness dependent influences on crop management concern the effectiveness of chemical spray applications and of liquid fertilizer applications which are reduced when leaves are wet. In addition, leaf wetness affects the grain moisture of cereals which, in turn, has an effect on the optimum harvesting date.

All this information is made available by the DWD in a time-critical way through fax and local telephone messages, and by modem links to individual users via existing computer communication networks (online services). In future it will be possible to distribute information via internet providers.

REFERENCES

Braden, H.: *The Model AMBETI - A detailed description of a soil-plant-atmosphere model.* Berichte des Deutschen Wetterdienstes, **195**, Selbstverlag des Deutschen Wetterdienstes, Offenbach am Main, 117 p. (1995).

Operational Use of MOS Forecasts in General Aviation (GAFOR)

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Abstract

The German Weather Service introduced MOS forecasts based on the EM-Model with predictands appropriate for aviation meteorology (Knüpffer, 1997). These have been adopted to provide forecasts of visibility and ceiling for areas of inhomogeneous terrain in the specific form of the GAFOR System.

Basis of the GAFOR-Forecast is the TAF-Guidance of our MOS-System which has been developed by Meteo Service, Berlin. For each of 100 German SYNOP stations, values of visibility and ceiling are being deduced from their probabilistic predictands. Using different threshold values of probability that conditions will be worse than the deduced categorical forecast provides different forecasts: PREVAILING (50 %), VARIABLE (30 %) and MINIMUM (50 %, refered to the worst station of every 2-hour-period). These single station forecasts are then blended with a weight taking into account the position and the representativity of the station with respect to the GAFOR-Area of concern. The weighting factor varies from 100 % (within the area), 90 % (nearby) to 80 % (Not quite close to the area, for which only few or no stations inside are available). Stations with a strong dependence on the general synoptic situation (e.g. strong upslope- or Föhn-effects) are disregarded to avoid problems during adverse situations.

Additional forecasts are given for all mountain stations so that they can be considered seperately in the GAFOR - Bulletin.

The final product for the aviation forecaster is a GAFOR-Guidance complying with the operational categories in GAFOR-Code using the following threshold values:

Category	X-Ray	Mike	Delta	Oscar	Charlie
Ceiling/ft	<500	500-1000	1000-2000	2000+	5000+
Visibility/km	<1.5	1.5 - 3	3 - 8	8+	10+

The indexed forecast is a combination of Vis / Cig - categories (e.g. 'Mike7' stands for Visibilty 'Mike' and Ceiling 'Delta'. All ceiling values refer to an area-specific reference level, which has been selected in such a way that a terrain clearence of 100 ft is provided for 'Mike'-conditions. For some areas, this scheme would result in unappropriate categories so that the reference level in these areas is below the highest topographic point, but only 5 % of the area is above that reference level.

The following table gives an example of an actual forecast. The second column gives the area-code (1: Ostfriesland; 21:Harz; 27:Thüringer Wald, Frankenwald and Fichtelgebirge (10544 Fichtelberg); 47 Rhön (10544 Wasserkuppe). Apart from the latest available observations, forecasts for visibility, ceiling and for the indexed category are given for 4 periods: lead-time 0-2, 2-4, 4-6 hours and TREND for the next three hours.

GAFOR - Categories based on TAF - Guidance - Forecasts

SYNOP - Observations until : 20.05.1997 04 UTC
EM3DA - Model-Run : 19.05.1997 12 UTC

Forecast-Period 1: 08-10 UTC 2: 10-12 UTC 3: 10-12 T: Trend

			Visibility					Ceiling					Index Category				
Issued	Area	PROB-Threshold	OBS	1	2	3	T	OBS	1	2	3	T	OBS	1	2	3	T
97052004	1	PREVAILING(50%)	M	M	D	D	D	D	O	O	O	O	M7	M6	D3	D3	D3
97052004	1	VARIABLE__(30%)	X	X	M	D	D	X	M	M	D	D	X	X	M8	D4	D4
97052004	1	MINIMUM___(50%)	X	M	D	D	D	X	M	D	D	O	X	M8	D4	D4	D3
97052004	21	PREVAILING(50%)	C	C	C	C	C	C	C	O	O	C	C	C	O	O	C
97052004	21	VARIABLE__(30%)	C	D	D	C	C	C	O	D	O	O	C	D3	D4	O	O
97052004	21	MINIMUM___(50%)	C	C	C	C	C	C	C	O	O	C	C	C	O	O	C
97052004	21	BERG_10453(50%)	C	C	O	X	D	C	X	O	X	X	C	X	O	X	X
97052004	27	PREVAILING(50%)	C	C	C	C	C	C	C	C	O	O	C	C	C	O	O
97052004	27	VARIABLE__(30%)	C	O	D	O	O	C	C	D	D	O	C	O	D4	D1	O
97052004	27	MINIMUM___(50%)	C	C	D	D	C	C	C	X	O	O	C	C	X	D3	O
97052004	27	BERG_10552(50%)	C	C	C	C	C	C	X	M	M	X	C	X	M2	M2	X
97052004	47	PREVAILING(50%)	C	C	C	C	C	C	C	O	O	O	C	C	O	O	O
97052004	47	VARIABLE__(30%)	C	O	O	C	C	C	M	D	M	M	C	M2	D1	M2	M2
97052004	47	MINIMUM___(50%)	C	C	C	C	C	C	X	X	M	X	C	X	X	M2	X
97052004	47	BERG_10544(50%)	C	C	D	D	C	/	C	X	D	O	/	C	X	D4	O

The GAFOR-Guidance has been in operational use since October 1996. The experience so far is positive and the acceptance by the forecaster community is surprisingly good. There are, however, specific deficiencies for cases when NWP-model forecasts fail or when conditions are triggered by very small-scale processes in the boundary layer. These cases are of special importance for aviation operations.

The verification is problematic because ceiling and visibility are only observed at specific stations in a GAFOR-Area, not the GAFOR categories for the whole area themselves. The program algorithm for the PREVAILING category has been applied for verification purposes. This is not necessarily the category which would be deduced from the observations by a forecaster, but it is an objective procedure. The verification results so far on this basis show a quality of the AUTOGAFOR forecasts comparable to the man-made forecasts. Although the bias of the automatic PREVAILING Forecasts is smaller than the conventional, there are more cases (about 3 % compared to about 1 % for manual forecasts) of underforecasting, i.e. conditions observed are two or more categories worse than forecast. These cases require amendments and are of potential danger to aviation; they can be avoided by using VARIABLE_30% - Forecasts which, however, brings in a slight bias.

The MOS forecast system is subject to continuous improvement, specially for those situations which are marginal for the statistical approach. The next step is the development of conditional climatologies of the predictands as an empirical function of the predictors to bring non-linear information into the system which it a priori does not have.

Knüpffer, K., 1997: Automation of Aviation Forecasts - Auto-TAF and Grid-Point-MOS. Preprint Volume: 3rd European Conference on Applications of Meteorology, Sep.23-26, Lindau, this Volume.

CLIMATOLOGICAL BASES FOR USING WIND ENERGY IN COMPLEX TERRAIN

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ABSTRACT

Introduction

The estimation of wind resources in non-flat and complex terrain has become more important for wind energy exploitation in recent years. However, tools for calculating wind conditions especially in complex terrain are hard to find. Within the scope of a project furthered by the *Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF)* the *Deutsche Wetterdienst (DWD)* developes an application program for the assessment of wind energy potential. As part of the whole concept wind charts are calculated by a mesoscale model using cluster analysis including a cluster splitting and calibration procedure. These results make up the basis for an application program especially for wind turbine siting in complex terrain. While the well known WAsP (≡ Wind Atlas Analysis and Application Programme) generally should be applied in flat or only slightly mountainous regions, this model fills in the gap left by WAsP. It features a nesting model, that uses the mesoscale output data under refinement of the flow fields to provide an instrument for detailed siting of wind turbines in complex terrain.

Wind Statistics in a Mesoscale Grid

Several steps are carried out to accomplish synthetic windstatistic data in a mesoscale grid over a specified area in complex terrain. One main part of this process is the mesoscale model to calculate wind in the atmospheric boundary layer. We chose the "Karlsruher Atmospheric Mesoscale Model" KAMM from the Institute of Meteorology and Climate Research in Karlsruhe for this purpose. It is driven by analysis of the geostrophic wind from an operational weather forecast model, which are clustered by a dimensional weighted Ward method. The cluster analysis builds up 100 clusters. They represent the original ensemble of the geostrophic winds and each cluster is given weight according to the number of single values assigned to it. These weights can, in a first step, be used for calculating statistical wind data near the ground from the output of the mesoscale model simply by weighting the model output with them. This leads to synthetic charts of mean wind speed and mean potential wind energy or to freqency statistics near the ground.

So far the method is independent of any wind data from meteorological stations as the model is only driven by geostrophic winds to determine the wind within the atmospheric boundary layer. However, it lacks of enough accuracy especially for applications on wind energy use. Therefore a calibration method is being developed to include reliable measurements from wind measurement sites. It consists of two parts:

1. A cluster splitting method which describes clusters not only by their centroid values but also by the region each cluster occupies in a wind direction-velocity space. Figure 1 shows the cluster spaces for the wind measurements of München-Riem. Splitting the cluster regions into several parts then makes it possible to transform clusters to a fixed definition of wind classes in a much better way than a simple classification of the cluster centroids.
2. The actual calibration step: It determines cluster weights from assigning near ground measured values to the clusterspaces at the corresponding grid point of the model area.

As an example, a chart of wind velocity statistic shown in figure 2 demonstrates the remarkable improvement by this method. The method of cluster splitting can be applied to the whole model area. Its results form the input of the application program APPLP for wind turbine siting.

An Application Program for Wind Turbine Siting

Preparation steps and Data Handling

The Application Program **APPLP** (to be spoken "*apple pee*") is considered as a link between the mesoscale output of the KAMM-model mentioned above and the concrete siting of a wind turbine.

On condition that the planned site lies within one of the three regions mentioned in the figure 3, APPLP can be applied. After chosing the site APPLP enables the wind energy user to take a brief look at the mesoscale statistics in the vicinity of the planned wind turbine. This includes tables and various graphics of mean wind speed, evaluated wind power and Weibull parameters within a radius of 3 km around the site. The data base consists of the mesoscale statistics in a grid of 1 km. If refinement of these data is desired — and this is the intention of APPLP — topographic grid data (altitude, landuse) in a high resolution of not less than 100 m are needed. APPLP provides tools to obtain these data using a drawing board and topographic maps. The land use data are transformed into roughness and zero plane displacement data.

The next steps of APPLP are carried out automatically even though they take a little time: After cutting out a reduced data set from the mesoscale output data extending about 3 km around the designated wind turbine site, the 100 flow fields are going to be reduced before they are handed over to the nesting model of APPLP. This reduction composes 12 new flow fields in a way, that every wind direction in steps of 30 degree is represented at the planned wind turbine site. In order not to lose the statistical information provided by the cluster analysis of the mesoscale data sector-wise Weibull parameters are calculated. It should be mentioned that the sector-wise Weibull parameters can only be calculated accurately because of the newly developed **cluster splitting method**, which multiplies the originally obtained number of 100 clusters by a factor of approximatly 5. The flow fields consisting of sector-wise mean wind vectors and Weibull parameters are handed to the nesting model for further refinement.

A Nesting Model for Surface-Layer Wind Flow over Complex Terrain

For adapting stationary mesoscale wind fields to topographic structures with a horizontal resolution of about 100 m a suitable microscale model with an appropriate spatial refining algorithm for the surface-layer wind field is necessary. It should also guarantee to run the complete program on a MS-DOS-compatible PC within a reasonable computing time. In order to ensure the applicability of APPLP in mountainous regions with strongly undulating topography and all varities of roughness change and zero-plane displacement, a new type of numerical surface layer wind field model had to be developed. A detailed description of the model would go beyond the limits of this paper. Therefore, it must be published later (KRUSE, 1997) and its main components will be listed here shortly:

A complete set of dynamical eqations in a finite difference formulation is used for numerical integration. The advection equations (equations of momentum and temperature) are solved numerically using a newly developed **'quasi-lagrangian' integration scheme**, which calculates stationary solution fields in a grid representation requiring very little computation time. This scheme is similar to the 'semi-lagrangian', but in contrast to the latter it is based on a 'stream line following' algorithm, which allows a very economic finite difference integration of strictly stationary balanced variable fields in flow direction. In order to eliminate or to diminish the 'orographically' induced mass inconsistencies of the flow field a non-hydrostatic pressure (correction) component is deduced from a divergence compensating, inviscid, irrotational correction component of the flow field. The nesting ability of the model is taken into account by solving the equations for microscale perturbation components of the wind field, which are considered to be superimposed 'quasi-linearily' to a given spatially coarse basic state of the (unperturbed) mesoscale flow. The perturbation components are forced by the micro-scale deviation of orography, roughness and zero-point displacement from the corresponding mesoscale fields.

The numerical solution of the model is attained successively in an approximative iteration procedure, which reduces the mass defect of the flow field step by step. First test runs of the model on a MS-DOS-compatible PC seemed to confirm the desired capability of the applied numerical computation method requiring a small number of iteration steps until the deficient divergence of the wind field is decreased to a tolerable measure.

KRUSE, B. (1997): *paper in preservation*

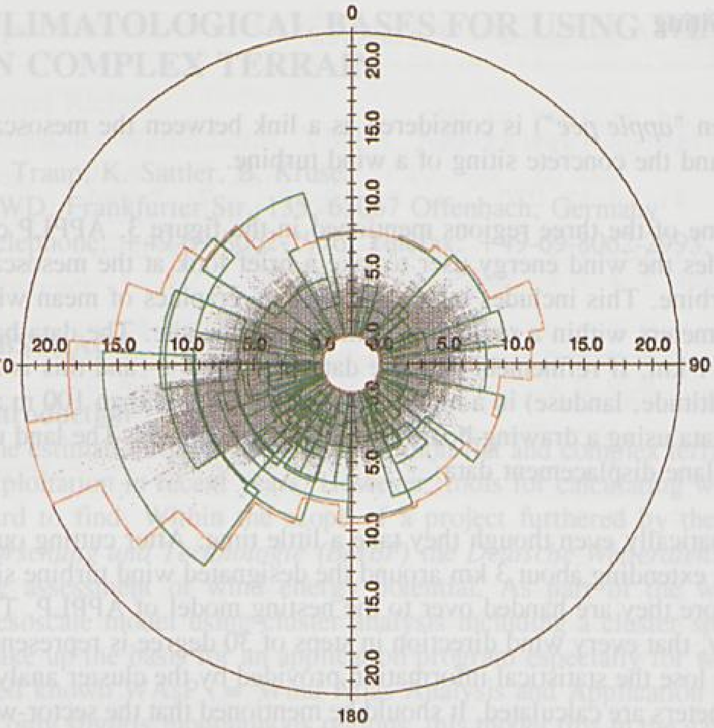

Figure 1: Clusterspaces (green) in chart of wind speed (radius) in ms^{-1} and wind direction (arc) in degrees from München-Riem at 10m a.g.l. Measured values are drawn in grey, their absolute upper borders of wind speed are shown in red.

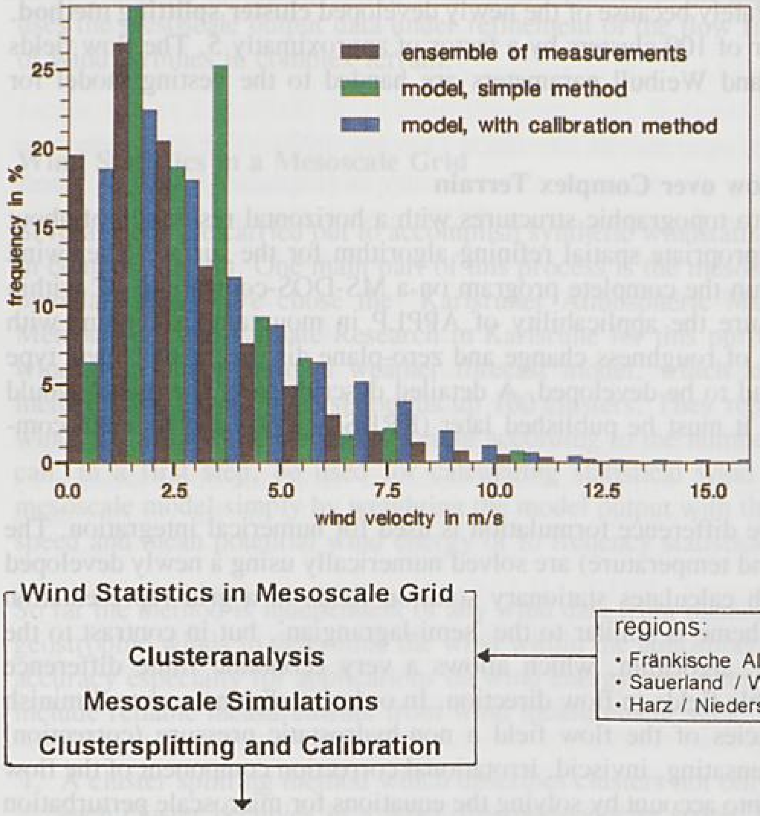

Figure 2: Frequency distributions of wind velocity for München-Riem at 10m a.g.l. The width of each velocity class is $1 ms^{-1}$ including three columns respectively.

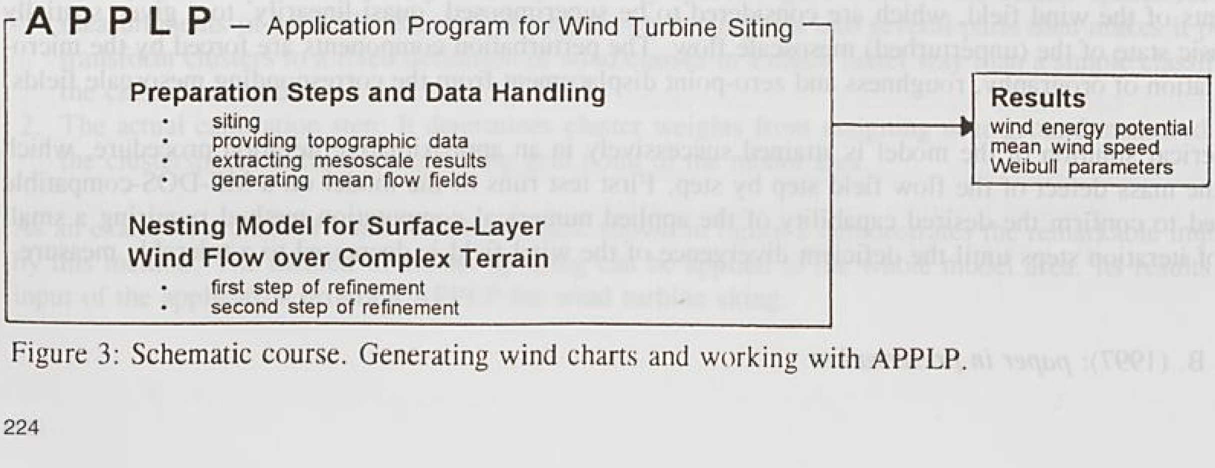

Figure 3: Schematic course. Generating wind charts and working with APPLP.

THE LONG-TERM BEHAVIOUR OF PRECIPITATION AND EVAPORATION AND ITS EFFECTS ON THE WATER BALANCE, TAKING THE LAKE STECHLIN CATCHMENT AREA AS AN EXAMPLE

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ABSTRACT

Water balance investigations of the Lake Stechlin and Lake Nehmitz catchment area are carried out since 1957 initiated in connection with the building-up of a nuclear power plant. Based on a dense network of measuring-points for precipitation, ground-water and lake-water levels many data are collected over 38 years fit for detailed studies on the water balance components and their long-term behaviour.

The most important topics of the investigations are

- the distribution of the precipitation amounts in the catchment area and the calculation of a long-term precipitation series ranging back to 1901
- the determination of the surface and subsurface runoff
- the long-term variations of the ground-water and lake-water levels including the resulting changes of water storage
- the determination of the catchment areal evaporation mainly composed of the amount of evaporation from the wooded land area and from the free water surfaces noting especially the influence of thermal discharge
- the separate calculation of the water balance components from the lakes and land surface areas
- the influence of the precipitation and evaporation variations on the long-term ground-water and lake-water level variations

The calculated annual means (1958/1995) of the water balance components resulting from the water budget equation

$$P_a - E_a - R_a \pm S_a = 0$$

amounts to following values: areal precipitation P_a = 653,5 mm, areal evaporation E_a = 549,3 mm and total runoff R_a = 104,2 mm while the long-term storage S_a = 0,8 mm is near zero.

The poster presents results of the methodical researches and the long-term behaviour of the water balance components. Furthermore the strong connection between the variation of precipitation and evaporation amounts and the long-term course of ground-water and lake-water levels is shown.

The results are useful to demonstrate man made influences on the water balance and to calculate long-term courses of ground-water and lake-water level variations.

THE ENVIRONMENTAL- AND AGROCLIMATOLOGICAL ATLAS OF BAVARIA WITH REGARD TO POSSIBLE FUTURE CLIMATE CONDITIONS

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1. AIMS

The Environmental- and Agroclimatological Atlas of Bavaria (**Rötzer et al., 1997**) forms a base for planning, consulting and research in agriculture, forestry, horticulture, ecology and landscaping. For every region of Bavaria the influences of the present climate and of possible future climate conditions on different plant species and their environments are shown. Different environmentally and agroclimatologically important elements are represented in maps and illustrations, commentaries and explanations are given for every chapter.

2. METHODS

After the environmental or the agroclimatological element is computed for every station, these values irregulary dispersed in Bavaria have to be mapped with a proper method of regionalisation. As these elements depend on various topographical parameters like height above sealevel, latitude, longitude, surface orientation, displacement in luff or lee and land use, multiple regression analysis with the topographical parameters as regressors is used to regionalize the elements. Based on a digital terrain model with 400m raster size the topographical parameters and thus the agroclimatological elements are calculated for each raster element using the regression equation and additionally spatial interpolation of the residuals in order to keep the regional characteristics of the stations (**Rötzer & Würländer, 1994**). Further steps to illustrate raster maps are classifying and colouring, shading with the terrain relief and adding cartographical information.

3. CONTENTS

3.1 PHENOLOGY

The average entrance dates of eleven different plant phases can be seen as maps. For the "beginning of flowering of the apple" the entrance dates of the hot year 1961 and of the cold year 1965 are mapped as well as the longterm means. Scenario maps are computed for the "beginning of flowering of elder" and for the "primary shooting of spruce". Further phenological studies were made on longterm trends and on the differences in the entrance dates between urban and rural regions. Phenological watches, which show the starts of the phenological seasons for 19 regions of Bavaria, were added to the atlas.

3.2 WATER BALANCE

The newly developed model "WHM" computes daily values for all components of the water balance. These are the potential and the actual evapotranspiration, the interception, the run off, the soil water content and - optionally - the irrigation. Using the *Penman*-equation the evaporation can be calculated by taking exposition and inclination into account (**Rötzer, 1996**). Thus about 60 maps and a great number of diagrams of different crops (maize, potatoes, wheat, barley etc.) as well as of the different land uses (watersurface, builtup-area, forest, grassland etc.) on different soiltypes are presented for present and possible future climates.

3.3 FROST

The average frequency of frost for every day of the year is depicted in diagrams for several climate stations. The threat of frost for apple- and sweet cherry-flowers can be determined for each region from two maps included in the atlas.

3.4 PHYTOPATHOLOGY

The climatological risk for the infection of *Venturia inaequlis, Erwinia amylophora* and *Phytophtora infestans* was mapped for Bavaria as longterm means and - if possible - as means of possible future climate conditions. Another map shows the maximum appearance of the young larvae of the potatoe beetle, which is the best point of time for control.

3.5 BEGINNING OF GRASSLAND GROWING

Using a temperature-model the beginning of the grassland growing for each rasterpoint of the map can be computed. These dates give the optimal time for fertilizing the grassland. A map for long time means as well as for a climate scenario are parts of the atlas. Diagrams are added in which the beginning of the grassland growing for single stations and years can be seen.

3.6 CLIMATOLOGICAL SUITABILITY FOR GROWING CROPS

Climatological suitability for growing crops means that from the map regions in Bavaria can be determined, in which - from the climatological point of view - a crop can be grown best or worst. This kind of map is calculated for sunflowers, beans and cucumbers. Besides average values additional maps are calculated taking possible future climates into account.

4. EXAMPLE: WATER BALANCE

As an example for the huge number of diagrams and maps which form the atlas the water balance of sugarbeet on loamy sand is presented here. In Figure 1 the daily values of all water balance parameters averaged over the years 1961 to 1990 can be seen.

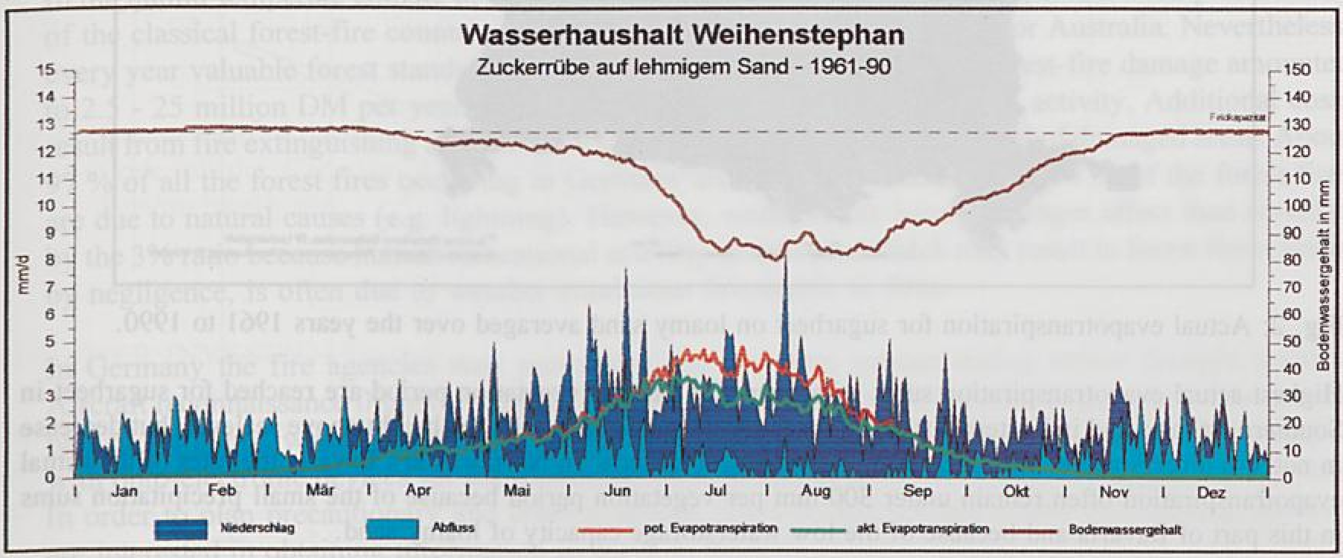

Fig. 1: Water balance of sugarbeet on loamy sand averaged over the years 1961 to 1990 on the climate station Weihenstephan near Munich. (dark blue: precepitation; light blue: run off; red: potential evapotranspiration; green: actual evapotranspiration; brown: soil water content)

While for the station Weihenstephan the average precepitation sum (dark blue) has its maximum in July/August, the run off values (light blue) are minimized at this time. On the other hand, the potential evapotranspiration (red line) rises from 0,2 mm/d in February up to 5,0 mm/d in July, whereas the soil water content (brown line) decreases from April until the end of August. Because of this decline the values of the actual evàpotranspiration (green line) are almost lower than the values of the potential evapotranspiration from the end of June until the end of August.

In Figure 2 the actual evapotranspiration is mapped for sugarbeet on loamy sand as mean values of the years 1961 to 1990.

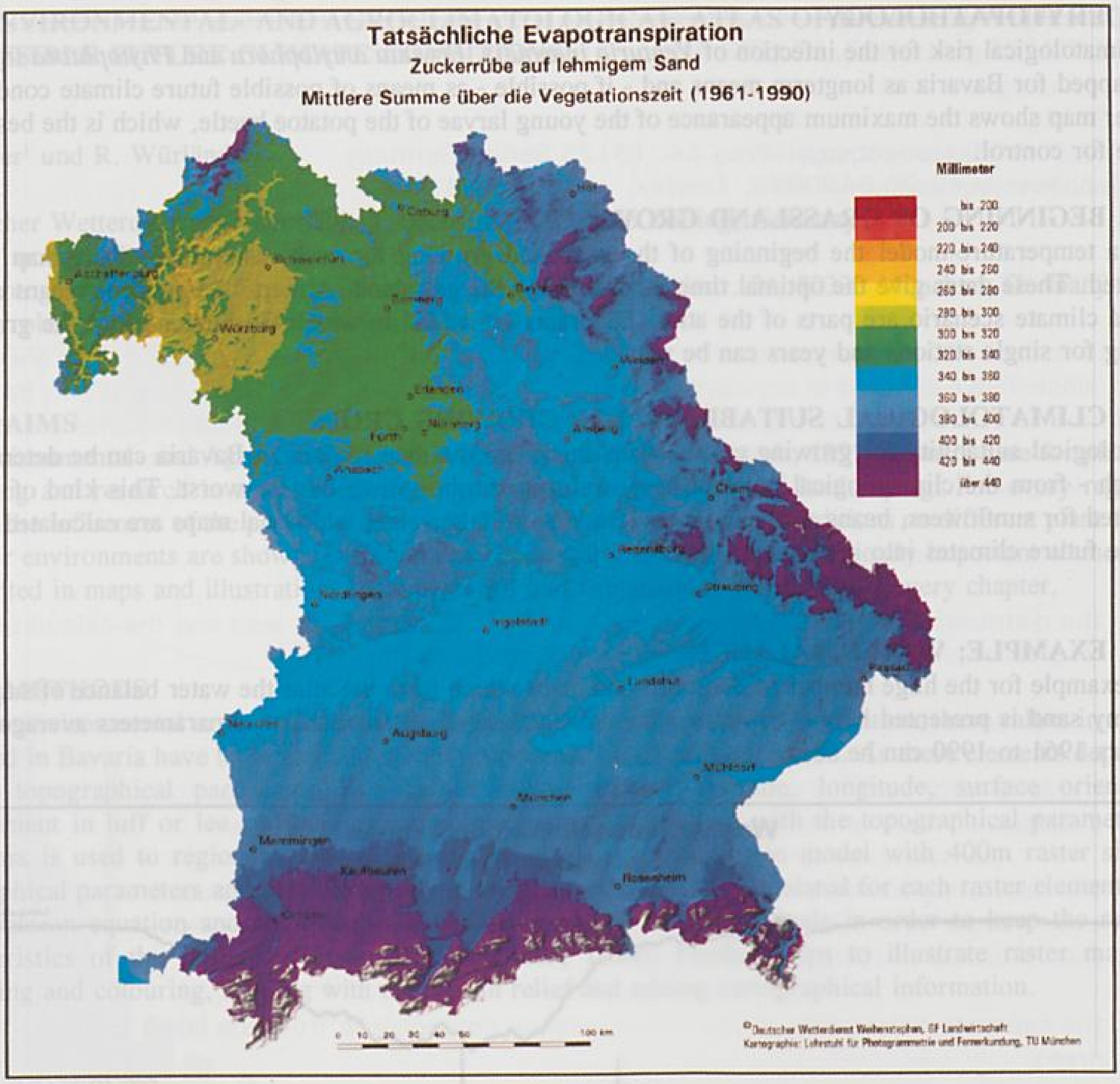

Fig. 2: Actual evapotranspiration for sugarbeet on loamy sand averaged over the years 1961 to 1990.

Highest actual evapotranspiration sums with over 420 mm per vegetation period are reached for sugarbeet in Southern Bavaria and in Eastern Bavaria. Generally the values rise with the height above sealevel, but decrease in nothern direction, i.e. with increasing geographical latitude. In Northwestern Bavaria the rates of the actual evapotranspiration often remain under 300 mm per vegetation period because of the small precipitation sums in this part of Bavaria and because of the low waterstorage capacity of loamy sand.

5. ACKNOWLEDGEMENTS

This project has been promoted by the Bavarian Ministry of Agriculture and Forestry.

6. LITERATURE

Rötzer, T., Würländer, R:, 1994: Neuartige phänologische Karten von Bayern und deren Anwendungsmöglichkeit in der Landschaftsökologie und Landschaftsplanung. Berichte der Bayerischen Akademie für Naturschutz und Landschaftspflege 18, Kirchzarten.

Rötzer, T., 1996: Neuartige Karten der Phänologie und des Wasserhaushalts von Bayern unter Berücksichtigung möglicher künftiger Klimaverhältnisse. Diss. TU München.

Rötzer, T., Häckel, H., Würländer, R., 1997: Umwelt- und Agrarklimatologischer Atlas von Bayern unter Berücksichtigung möglicher künftiger Klimaverhältnisse. Deutscher Wetterdienst Weihenstephan.

THE FOREST-FIRE WEATHER FORECAST OF THE DEUTSCHER WETTERDIENST

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ABSTRACT

During the spring and the vegetation period the Deutscher Wetterdienst daily predicts the weather-dependent risk of the outbreak of forest fires. The present status of the routine forecast scheme, which consists of regional fire-risk indices and a water balance scheme, is described.

INTRODUCTION

In the humid-temperate climate of Germany forest-fire danger is of minor importance compared to that of the classical forest-fire countries in southern Europe, northern America or Australia. Nevertheless, every year valuable forest stands are destroyed. Between 1991 and 1995 forest-fire damage amounted to 2.5 - 25 million DM per year depending on drought severity and human activity. Additional costs result from fire extinguishing activities and from the reforestation and renewal of damaged areas. About 97 % of all the forest fires occurring in Germany are ignited by humans. Only 3 % of the forest fires are due to natural causes (e.g. lightning). However, weather may have a stronger effect than revealed by the 3% ratio because human recreational activitiy in the open, which may result in forest fires caused by negligence, is often due to weather conditions favourable to fires.

In Germany the fire agencies start preventive fire detection actions during severe drought periods. Aircraft reconnaissance flights are carried out over defined areas with high fire danger and in the eastern part of Germany, where forest fires are most likely to occur due to sandy soils, towers are equipped with opto-electronic devices for the identification of smoke plumes, or they are manned by observers. In order to plan precautionary and control actions forest authorities and forest fire-fighting agencies are interested in obtaining information as early as possible on those weather conditions which favour the outbreak and the spreading of forest fires.

One of the objectives of the Deutscher Wetterdienst (DWD) is to analyze the forest-fire risk potential of the weather. In order to assess the daily state of the risk, the Deutscher Wetterdienst operates a forecast tool which calculates forest-fire indices on the basis of data from the synoptic network complemented by synthetic predictions of the numerical weather forecast model. For this purpose the so-called AMBER software (AMBER = AgrarMeteorologisches BERatungsprogramm = agrometeorological advisory programme), which contains forest-fire modules, runs daily on a PC and produces 5-day forecasts. Through its agrometeorological advisory service the DWD transmits early warnings to the forest-fire agencies and supports their control programmes by weather and fire severity forecasts as the initial step of preventive fire management. In addition, warnings are made available to the public in audiovisual and print media in order to minimize the human effect on the possible outbreak of forest fires.

FOREST-FIRE INDICES

It is generally known that dry and windy weather promotes the ignition and propagation of forest fires because of its effects on the water content of dead and living organic matter and on the oxygen supply. At present two traditional German risk indices developed in the 60s and adjusted to forest-fire activity are calculated on a daily basis. One is based on the water deficit, i.e. on potential evapotranspiration and the amount of rain, averaged over a continuous 5-day period starting in March. Potential evapotranspiration is calculated in a simplified manner using only the noon saturation deficit. Subsequently, the mean water deficit is converted into a 5-class forest-fire warning scheme. The other index is an accumulating one which starts in mid-February and takes the product of air temperature and saturation deficit into account. Additionally, corrections are made to the summation value on those dates when special thresholds of wind speed, rain amount and snow cover are exceeded and when well-defined phenological stages of tree development occur. The final summation value is also converted into a 5-class forest-fire warning scheme. This second index has a longer meteorological memory and responds a little faster to changing weather conditions. Fig. 1 shows the behaviour of the meteorological core functions for the medium fire-severity class in relation to relative humidity and air temperature.

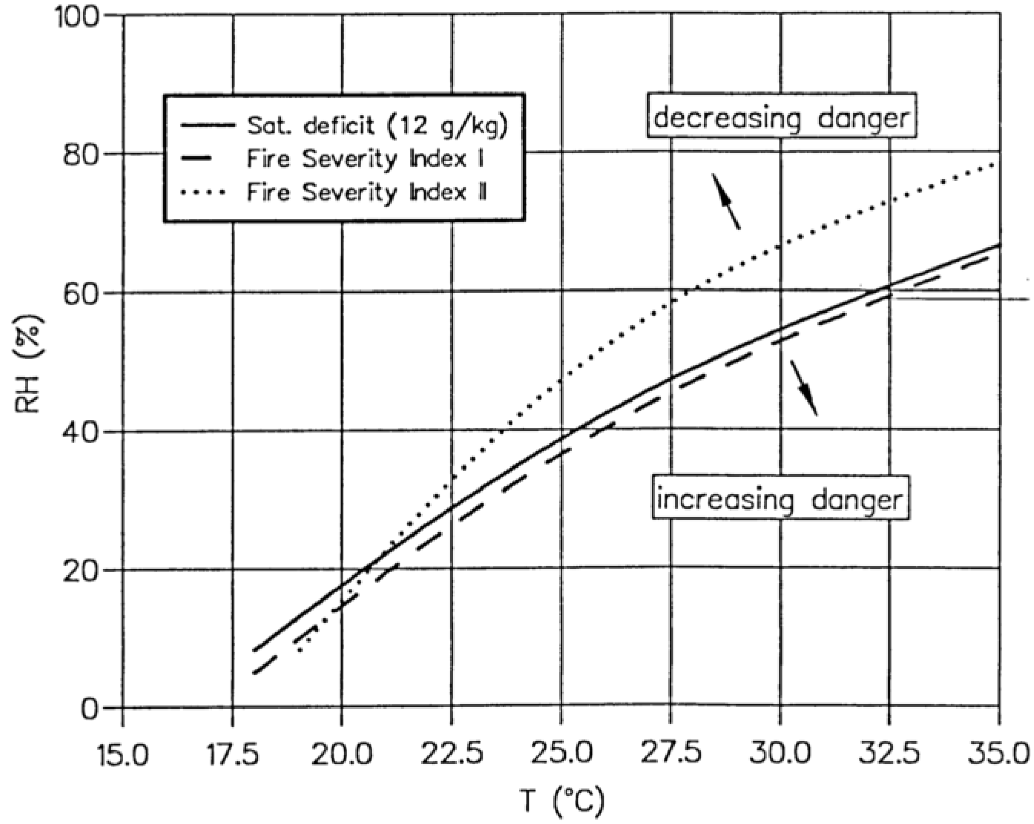

Fig.1: Comparison of the core functions underlying the two German forest-fire indices in the relative humidity - temperature plane.

NEW WATER-BALANCE AND FUEL-MOISTURE SCHEMES

A second module calculates the water balance of a forest using a single-layer soil hydrology model. One part of the falling precipitation reaches the forest floor directly through the canopy gaps while the other part is intercepted and may only drip off to the ground when the interception reservoir is filled. The changing soil moisture feeds back to forest transpiration by controlling the stomata activity. Transpiration is calculated by the Penman-Monteith model. External forcing is given by hourly data of temperature, relative humidity, wind speed, downward directed longwave and shortwave radiation and precipitation measured in the open. The soil-moisture deficit and the ratio of actual to potential transpiration give an indication of forest-water stress.

The moisture content of dead fuel is calculated using the same input data. Forest litter loses water by evaporation which is controlled by a water-content dependent resistance and an aerodynamic one, while water uptake is caused by dew and rainfall. Runoff occurs when surface water exceeds a threshold maximum. The water-uptake rate is proportional to the depression of the water content below a maximum threshold. Fig. 2 compares the results of the fuel-moisture scheme with the one of the Canadian forest-fire model and shows adequate agreement between the two approaches.

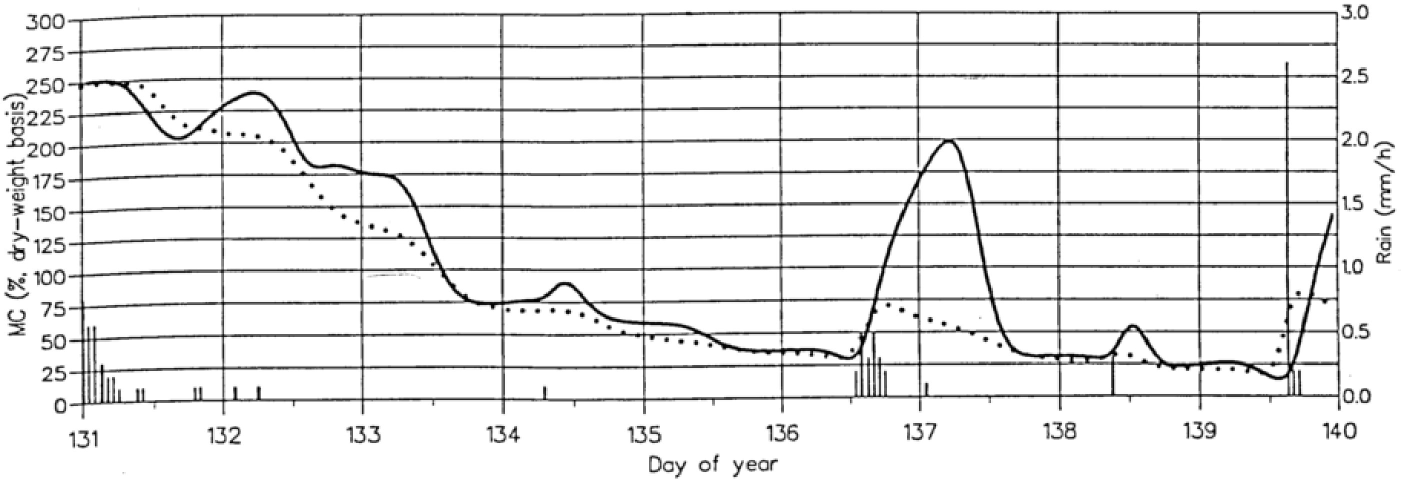

Fig.2: Comparison of the DWD fuel-moisture scheme (continuous line) with the Fine-Fuel Moisture Code of the Canadian Fire-Weather Index (dotted line). Input data are taken from the Braunschweig site.

FURTHER INVESTIGATIONS

The water balance and the fuel-moisture schemes were developed only recently and still need proper validation with severe fire-weather conditions. This will be done in the near future in order to include the new module in the daily routine runs next year.

ACKNOWLEDGEMENTS: I would like to thank P. Lex, forestry division at Lüneburg, for helpful discussions.

PREDICTION ADJUSTMENT TOOLS INCLUDED IN THE WELS-SYSTEM

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1. Introduction to the WELS-System

The WELS system (see Teixeira 1994, Reiter and Teixeira 1994, Teixeira and Reiter 1995, Spreitzhofer 1996) is a weather prediction scheme, developed by the American WELS Research Corporation and currently operationally employed in parts of the United States, chiefly by traffic operation centres, ski resorts and agricultural companies (internet-info: http://www.weatherpro.com/). Recently the system was transferred to Central Europe (Spreitzhofer and Steinacker, 1996 and 1997) and subsequently testwise utilised by the winter road maintenance service of Vienna, by the Austrian aviation service and by the Institute of Meteorology, University of Vienna. All processing, including the model forecast, is done on cheap, yet high-end (e.g. Pentium-type) PCs.

The system is based upon a number of unconventional concepts like that of hybrid modelling: an independent, grid-based mesoscale forecast model, integrating the full set of prognostic equations, delivers 24 hour-predictions which can be manipulated and enriched by means of a Graphical User Interface (GUI). Beside the numerical forecast model and the GUI, important system components include modules related to decoding, geographic information and chart display. The principal features of these five subsystems are as follows:

- **The decoding module.** This is responsible for the pre-processing of raw surface and upper-air observational data, and for the optional restructuring of forecast data from global models which may be used to implement flexible boundary conditions and to improve the initial fields.
- **The geographic information module.** This represents a GIS (Geographic Information System) structured for meteorological applications. It includes files containing coordinates of road-, river- and boundary segments and of major cities.
- **The numerical prediction model** (an overview is offered by Spreitzhofer, 1996). This is responsible for the stepwise integration of the hydrodynamic system of primitive equations. It delivers 24-hour forecasts of convective and large-scale precipitation, temperature, specific humidity, wind, geopotential and surface pressure.
- **The chart display module.** This serves the production of conventional meteorological charts in various forms. Input fields are weather observations, forecast fields or topographic data. Displayed are station values, the objective analysis and derived fields.
- **The Graphical User Interface (GUI).** This can be used on-site to improve the forecast quality by the incorporation of additional data (sometimes not available at a central office) into the prediction process, as soon as observational evidence begins to indicate that the forecast is off-track. It has been designed for use by non-specialists; its handling is therefore relatively easy and entirely based on mouse-point-and-click actions.

2. Details about the Graphical User Interface

The GUI (Spreitzhofer 1997, Teixeira and Reiter 1995) is a user-interactive, object-oriented and graphics-based post-processing tool which includes approaches related to artificial intelligence. The efficient data management permits fast interaction between, and display as well as manipulation of, terrain and weather forecast data.

A variety of terrain-visualisation facilities is offered, including the map display of elevation, slope and compass, the accentuation of certain height intervals and a built-in zoom function. The output of the numerical model, available in three-hourly intervals over the 24-hour forecast period, can be represented in the GUI and optionally be printed in combination with the terrain characteristics for specified areas (see Fig. 1). The separate or coupled display of a number of meteorological parameters such as temperature, wind speed and direction, dewpoint depression, precipitation potential, rain and/or snow (related to time intervals or cumulative) is possible, and automatic time loops can be initiated. The complete forecast for a specific point in the form of forecast histograms plus terrain and astronomic characteristics of the chosen location can easily be called by mouse-click actions (see Fig. 2).

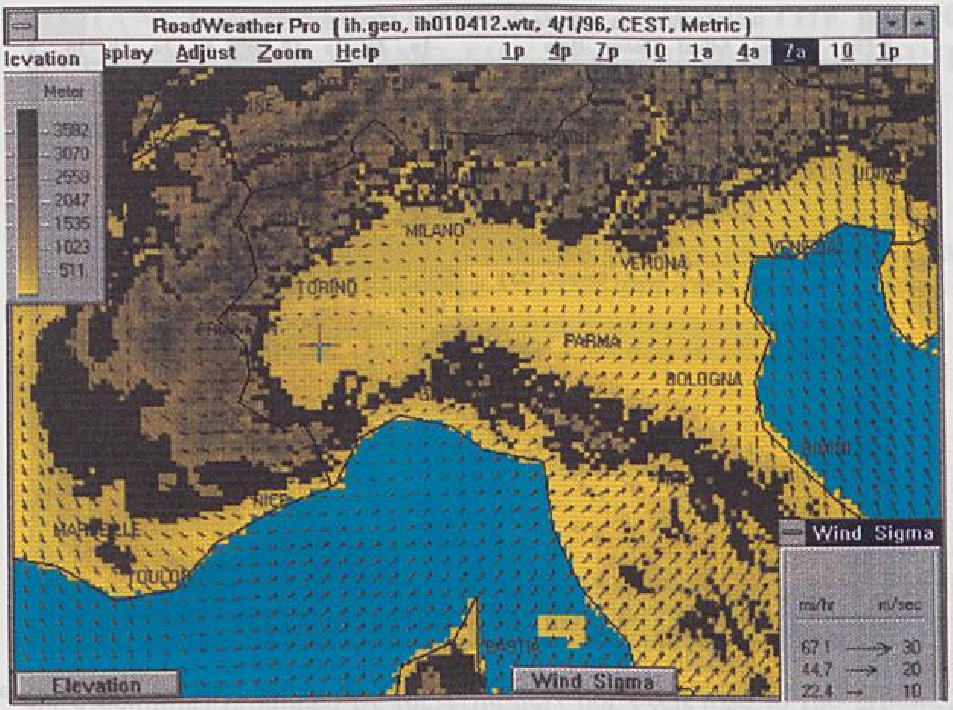

Fig. 1. Map display of the topography of Northern Italy; elevations between 500 and 1200 m are drawn in black. Superimposed is the 18-hour wind forecast for the lowest model surface (approx. 700 m above MSL), valid for 02 April 1996 0600 UTC (= 7 a.m. local time). The cross marks the centre of a predicted surface cyclone.

Fig. 2 shows for the clicked-on location a predicted snow accumulation of up to 5 cm per 3 hours for the first part of the forecast period, the precipitation turning into rain by the end of it. At 7 p.m. the predicted temperature was 0°C, but less than -2°C were actually measured. Due to a number of built-in post-processors, the GUI provides the opportunity to correct this obviously derailing forecast. A simple mouse-click at the adequate position in the temperature prediction histogram helps to adjust the temperatures for the rest of the forecast period and the predicted precipitation as well (Fig. 3). Due to the now colder conditions precipitation is forecast in the form of snow over the whole period, with an increased maximum accumulation of up to 8 cm per 3 hours. The new end-of-the-period temperature value corresponded well with the observed one.

Beside the surface temperature, there are several other parameters that can be adjusted or set for a specific location in order to improve the model forecast. As an example, the ground temperature setting (thawed, lightly or deep frozen) exercises an influence on the snow/liquid ratio, and both the chosen ground snow cover (none, partial or total) and cloud cover (five categories from clear to overcast) control the shape of the predicted surface temperature curve.

3. Outlook

The successful utilisation of the WELS-system in the United States and over Central Europe proved that operational meteorological models can work effectively in a distributed mode to deliver real-time observational and forecast products in support of tactical decisions. However, much can be done in the future directed towards the further improvement of the system:

- The continuous assimilation of local and regional observational data could be included in the GUI. Thus it would be possible to update derailing forecasts automatically, rather than by a local user adjustment.
- GUI-type displays could be expanded into three dimensions.
- Current observations from a variety of sources (standard sensors, radar, satellite, lightning, etc.) could be included into relevant forecast displays (already partly implemented in the US-version of the WELS system).

Acknowledgements

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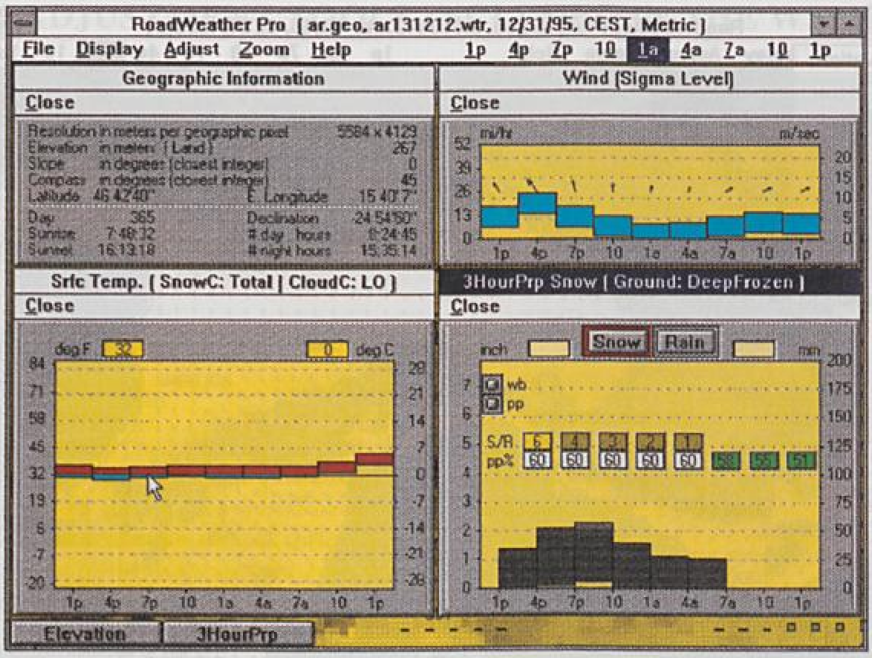

Fig. 2. Forecast histograms for a location near Spielfeld in southern Austria; the 24-hour prediction period starts at 1200 UTC on 31 December 1995. Upper left window of the display shows geographic and astronomic characteristics of the clicked-on location. Upper right window exhibits wind speeds (block diagram) and vectors (arrows). In the lower left surface air temperatures are shown, and the lower right window offers options to display snow or rain accumulation per 3 hourly intervals. Numbers in the upper boxes indicate the snow/liquid precipitation ratio selected by the model, those in the lower boxes present the percent potential for snowfall (white boxes) or rain (green boxes). Wind speed, temperature and precipitation displays include error bars.

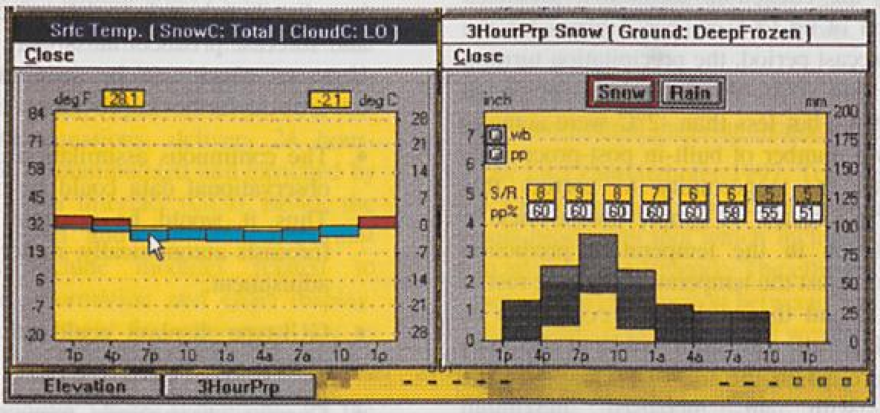

Fig. 3. Temperature and precipitation forecast histograms valid for the same date as in Fig. 2, after the manual adjustment of the temperature forecast at 7 p.m. local time by a mouse click (check the arrow position).

References

Reiter, E. R. and Teixeira, L. (1994). *RoadWeather Pro™ User Manual, Version 2.03.* WELS Research Corporation, Boulder (CO), 179 pp.

Spreitzhofer, G. (1996). *The WELS-weather prediction system: Adaptation and validation for the Alpine region.* Ph.D.-Dissertation, Inst. für Meteorol., Univ. Wien, 108 pp.

Spreitzhofer, G. and Steinacker R. (1996). Adaptation of the WELS-weather prediction system to Central Europe. *Proceedings of the 8th International Road Weather Conference in Birmingham* (UK), April 1996: 95-105.

Spreitzhofer, G. (1997). Application of post-processing tools to improve visualization and quality of numerical short-range predictions over Central Europe. Accepted by *Meteorol. Appl.*

Spreitzhofer, G. and Steinacker R. (1997). *Kurzfristige Schneeprognosen für den Straßenwinterdienst.* Bundesministerium für Wirtschaftliche Angelegenheiten, Vienna, Strassenforschung, Heft 466 (part 2), 59 pp.

Teixeira, L. (1994). *Automated meteorological data reception, analysis and prediction suitable for personal computers.* Ph.D. Dissertation, Colorado State Univ. (Fort Collins), Dep. of Civil Engineering.

Teixeira, L. and Reiter, E. R. (1995). Hybrid modeling in meteorological applications; Part II: An operational system. *Meteorol. Atmos. Phys.*, 55: 135-149.

ENHANCED RESOLUTION ANALYSIS OF THE ATMOSPHERE OVER THE ALPS USING THE FINGERPRINT TECHNIQUE

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EXTENDED ABSTRACT

Operational we,aather prediction models with a spatial resolution in the order of a few kilometers are now being under development. The conventional meteorological observing network is not adequate to resolve the small scale features (meso-beta and meso-gamma) produced by these models not even lose to the ground in areas with (automatic) mesonets. This implies a fundamental problem in model initialization, monitoring and validation. Space-borne as well as earth based remote sensing techniques (Satellite, Radar, etc) fill part of the gap, several meteorological parameters however are not being retrieved with the necessary accuracy.

Considering the above facts, the first guess fields of some atmospheric variables which are originating from short range forecasts of very high resolution models cannot really being refined by observational data directly, what concerns the smallest scales. The gap between the resolvable structures by observational data and high resolution models may be filled by the fingerprint technique at least over mountainous terrain.

What is the fingerprint technique ? The basic idea behind is the utilization of a priori knowledge of atmospheric structures. Similarly to the optimum interpolation technique, where we make use of the a priori knowledge of structure functions, we consider here atmospheric structures forced by the underlying (complex) terrain. Mountains like the Alps force the atmosphere basically by two different physical mechanisms. On the one hand a flow impinging the Alps is rearranging the mass and flow field in a well known fashion, i. e. windward blocking and flow deflection with an orographic high pressure ridge and leeward acceleration with a presssure trough. On the other hand the differential heating or cooling of elevated and rough terrain produces heat lows or cold highs respectively with a corresponding direct thermal circulation. Each single valley, pass and mountain ridge produces its characteristic mesoscale regime, depending on season, diurnal cycle and large scale (synoptic) situation. These mesoscale regimes may be modelled quite accurately with the aid of a high resolution topographic data set (digital terrain model). Such data sets with a resolution in the order of 1 km horizontal resolution are now available worldwide and have been used by the authors to create the dynamically induced perturbation fields (dynamical fingerprints) an the thermally induced disturbances (thermal fingerprints)

over the larger Alpine area. An example of the dynamical and thermal fingerprint is plotted in fig 1. One clearly can see, how the heat low /cold high (left) is located over the major mountain ridges and produces gradients across the slopes and in the Alpine valleys, corresponding to thermally driven circulations. The right part shows the dynamical fingerprint for a southerly/northerly flow, producing extremely concentrated gradients across major ridges, whereas in the valleys and surroundung plains the gradients become much more reduced.

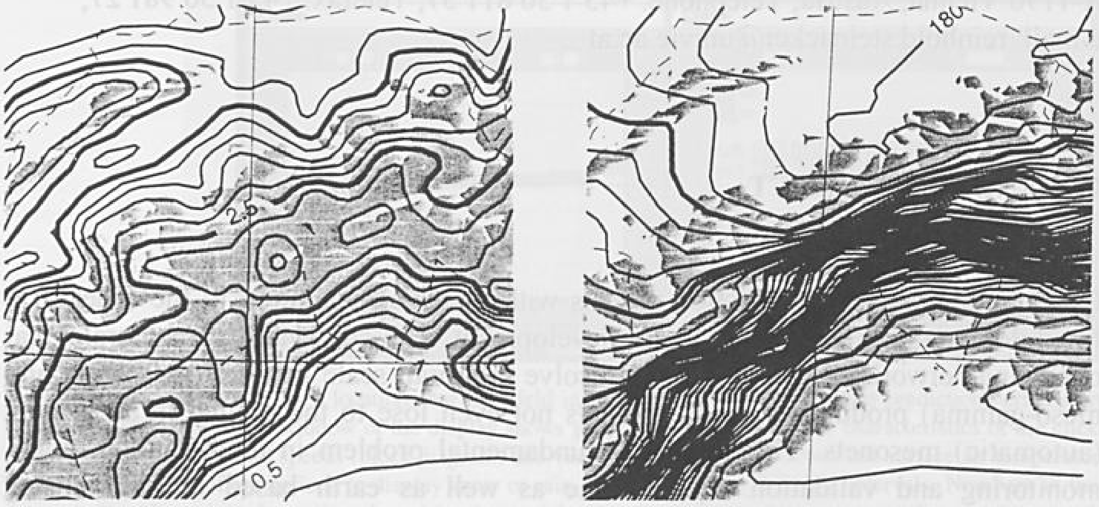

Fig. 1: Thermal (left) and dynamical (right) fingerprint of the sea level pressure field (relative units) over part of the Alps (Switzerland) using a 5 km grid. Further explanation see text.

The relative fields of the fingerprints are now used to downscale the fields derived from the much less dense observational network. This is simply done by the computation of a weight-factor at each gridpoint of the analysis domain, relating the amplitude of the idealized fingerprint to the actual observations. For that purpose a

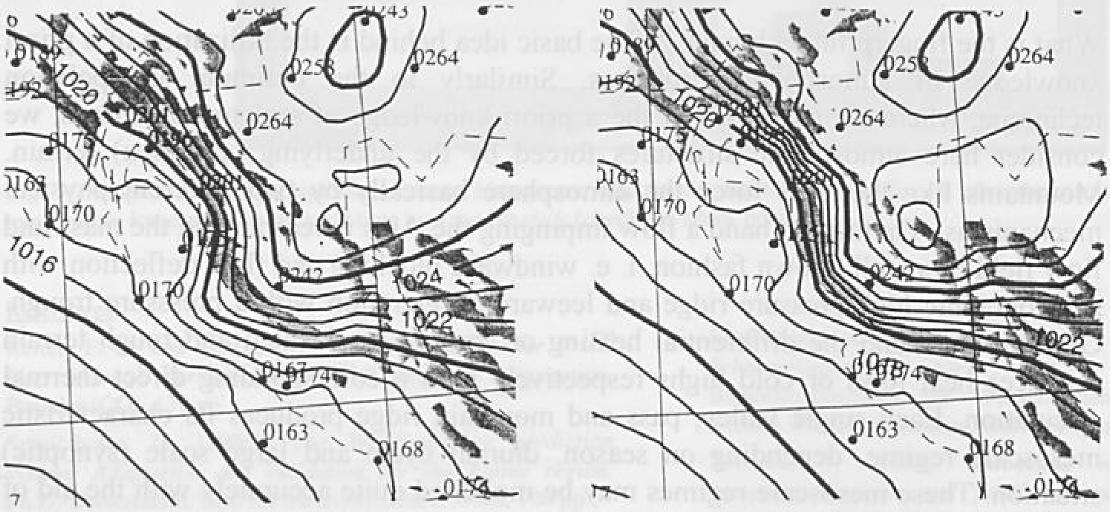

Fig. 2: Sea level pressure analysis on 12 December 1996, 09 UTC during a bora case along the Dinaric coast, using a 20 km grid. The isobaric spacing is 1 hPa. A conventional analysis is shown left and the downscaled version right. Further explanation see text.

laplacian is computed from observations close to the gridpoint and in addition from the idealized field taking values at just the same locations like the observing stations. The local computation of the factors allows also the downscaling of rather complicated situations, e. g. the eastern part of the Alps being in a southerly flow (positive factors) and the western part in a northerly flow (negative factors). Fig. 2 shows an example of a conventinal (left) and downscaled with the fingerprint technique analysis (right) of sea level pressure analysis over the Dinaric Alps. Although the station network in that area is quite dense to allow for a strong gradient along the barrier, the downscaled field shows an increased gradient following much more precisely the topography.

Analyses downscaled with the fingerprint technique have been operationally computed in a three hourly interval for sea level pressure, potential temperature and equivalent potential temperature during the last several months. They have proven to be a valuable tool to nowcast small scale features in the Alpine area and to early recognize model derailments. The validation of a very high resolution forecast models with this analyses is a further plan of investigation. Further developments for a three dimensional approach to analyze the lower tropospere over the Alps are under way.

Acknowledgements: Thanks are due to the Fonds zur Förderung der wissenschaftlichen Förderung (Project P10285-GEO) for financial assistance and the Zentralanstalt für Meteorologie und Geodynamik, Vienna for providing the observational data.

Presentation of Printready Weather Reports in the Media

All the weather fit to print

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ABSTRACT

What do readers expect?

A broad spectra of people form the readers of weather reports in newspapers. For many of them the printed weather report is the most detailed form of weather information they get, as weather reports on Radio and TV are very often consumed in a passive way. Investigations on readers behaviour showed, that 25% to 30% of the readers pay considerate attention to the weather report in a particular newspaper.

A quick overlook for the most important weather feature for the present day especially in business travel regions is a very common behaviour for readers of papers with detailed information in politics and economy, where the main interest lies in gathering political and economical background data. As soon as there is more time for the reader available, patterns of behaviour change: Special interests for nature or science evolve more explicit, in these cases weather reports are sources of information which concern both scientific and nature orientated interests.

On one side therefore a service function of the weather report for practical use can be discerned. In these cases weather reports should be as short, compact and clear as possible. Readers with particular interest in weather on the other hand expect explication of current weather phenomena in an easy understandable way. The study of well prepared graphical displays for all features is in these cases done with devotion and interest. This group of readers is generous with feedback to the editor; the weather report triggers long discussions about the physical mechanisms that move earth and heaven.

A third group of readers shows occasional interest in weather reports and tends more to screen the paper for catastrophes and extreme events. Weather phenomena can be very often one of them, hurricanes, floods or heat spells and avalanches are the most prominent features of this type. Full coverage of these events meets the needs of eerie things of these spectators. Leant back at home nature in its most violent form finds its way to the reader. At the same time a sort of confirmation is given to a current unhappiness with the actual weather. The heat wave of the last two weeks is the worst since 1900, or the local lack of snow reached record values during last winter... In these cases pure statistics are only one form of the wanted information, most interest finds the headline with an emphasis on the "never before observed event".

What comes out best in printed weather reports?

The graphical display possibilities in Print media and also the more and more employed colours allow satellite pictures to be shown in great detail, weather maps are in Austria still the common feature of all reports. In former times these maps were often mere copies of the surface analysis of the meteorologist, today reduction of contents to the essentials and better graphically layouts are generally desired. In some cases surface fronts are drawn, but mostly the information is reduced to isotherms over the continent and icons for the dominant weather features in particular places.

Diagrams for temperature developments, environmental or pollution characteristics are in many cases more informative than text information to these themes. Threshold values for different warning levels and their relation to the actual measurements values can be easily displayed for different components of pollutants.

Most papers require satellite pictures for a general overview. This element replaces in some cases the traditional weather map. Readers are trained by television weather reports to locate the position of depressions and fronts.

Which products does ZAMG deliver?

Since the start of printready weather reports for the media in autumn 1995 75% of the newspaper market has been supplied with the new form of weather reports. The individual papers chose the layout and the form of their weather page from a catalogue of elements that contains classical forms of weather reports for an area within Austria or Europe and weather related reports about e.g. the effect of weather on health or the occurrence of pollen in the atmosphere. The co-operation with other institutions and authorities proofed to be helpful for both sides for the production of weather pages. Credit to the sources of theses information are given in the text.

Products available:

Weather maps with Isobars, Isotherms, Icons for weather situation, Cloudiness etc. for

- Europe
- Austria
- Federal Regions

Satellite pictures in combination with above mentioned elements

Graphs for

- Mountain weather
- Pollutants
- Mid range weather forecast
- Temperature developments
- Moon phases

Text elements

Synoptic overview
Explanation of weather elements of satellite pictures
Area forecasts on different scales
Mountain weather
Statistics
Health weather
Air pollution development

Lists

Weather in major cities
Astronomical information
Pollutants

ZAMG produces weather reports in a combination of centralised and decentralised form. Elements which are used more than once are produced in Vienna and transmitted to the regional offices, local information is added at place. Therefore a close contact can be held to the local needs of information providers and latest meteorological information is included in the text.

The different elements are combined with Freehand Graphics and Quark XPress Pages on Apple Computers. Texts are corrected for typing mistakes, that the printing can be done without delay. The printable files get transmitted to the print systems via ISDN.

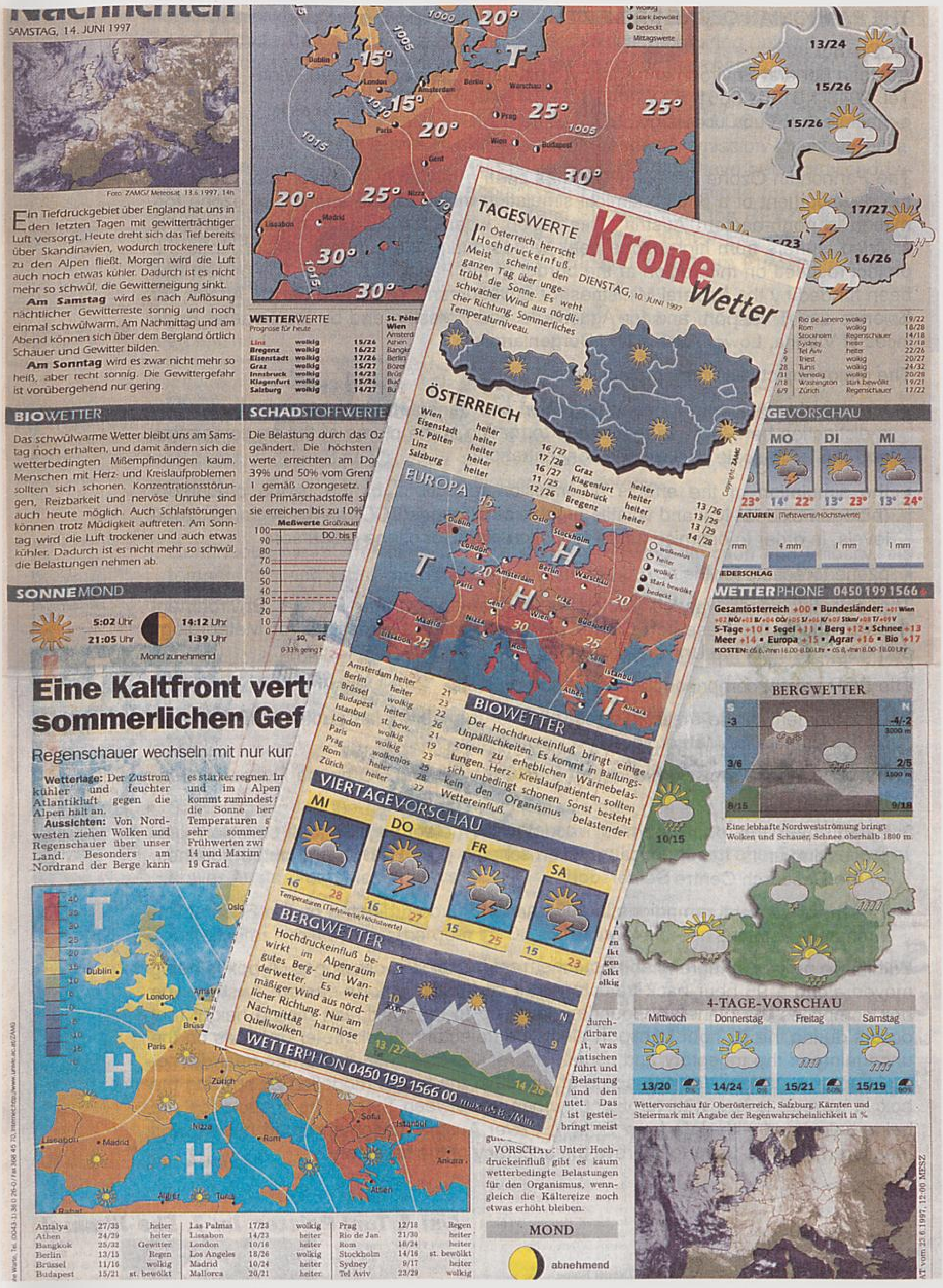
Much attention had been paid to avoid a breakdown of the system and the transmissions. Redundant security version of each page exist within the different local representations of ZAMG. Computer breakdowns and Computerline interruptions can both be surpassed within short time.

Future plans

Most editors anticipate the change between printed and electronic media that started in the Nineties. Print media will continue to be important in the future, but a growing share of the market will be covered by electronic media. Internet versions of newspapers appeared in Austria in the last year and proofed to be successful. Some editors widened their fields of activity for local cable TV.

ZAMG has in both cases started to provide weather reports for these media. The production is done in a similar way as the printed version, but the output of the files is graphically filtered for the special application.

Contents of weather information seem to change slower than the graphical presentation. New elements will probably cover the wide fields of consequences of particular weather situations in other areas on health, sports and economy.



Nachrichten

SAMSTAG, 14. JUNI 1997

Foto: ZAMG/ Meteosat 13.6.1997, 14h

Ein Tiefdruckgebiet über England hat uns in den letzten Tagen mit gewitterträchtiger Luft versorgt. Heute dreht sich das Tief bereits über Skandinavien, wodurch trockenere Luft zu den Alpen fließt. Morgen wird die Luft auch noch etwas kühler. Dadurch ist es nicht mehr so schwül, die Gewitterneigung sinkt.

Am Samstag wird es nach Auflösung nächtlicher Gewitterreste sonnig und noch einmal schwülwarm. Am Nachmittag und am Abend können sich über dem Bergland örtlich Schauer und Gewitter bilden.

Am Sonntag wird es zwar nicht mehr so heiß, aber recht sonnig. Die Gewittergefahr ist vorübergehend nur gering.

BIOWETTER

Das schwülwarme Wetter bleibt uns am Samstag noch erhalten, und damit ändern sich die wetterbedingten Mißempfindungen kaum. Menschen mit Herz- und Kreislaufproblemen sollten sich schonen. Konzentrationsstörungen, Reizbarkeit und nervöse Unruhe sind auch heute möglich. Auch Schlafstörungen können trotz Müdigkeit auftreten. Am Sonntag wird die Luft trockener und auch etwas kühler. Dadurch ist es nicht mehr so schwül, die Belastungen nehmen ab.

SONNEMOND

5:02 Uhr · 21:05 Uhr · 14:12 Uhr · 1:39 Uhr · Mond zunehmend

WETTERWERTE

Prognose für heute

Linz	wolkig	15/26
Bregenz	wolkig	16/22
Eisenstadt	wolkig	17/26
Graz	wolkig	15/27
Innsbruck	wolkig	14/23
Klagenfurt	wolkig	15/26
Salzburg	wolkig	14/27

SCHADSTOFFWERTE

Die Belastung durch das Oz... geändert. Die höchsten ... werte erreichten am Do... 39% und 50% vom Grenz... 1 gemäß Ozongesetz. ... der Primärschadstoffe ... sie erreichen bis zu 10%...

Rio de Janeiro	wolkig	19/22
Rom	wolkig	18/28
Stockholm	Regenschauer	14/18
Sydney	heiter	12/18
Tel Aviv	heiter	22/26
Triest	wolkig	20/27
Tunis	wolkig	24/32
Venedig	wolkig	20/28
Washington	stark bewölkt	19/21
Zürich	Regenschauer	17/22

...GEVORSCHAU

MO · DI · MI

23° · 14° 22° · 13° 23° · 13° 24°

...RATUREN (Tiefstwerte/Höchstwerte)

mm · 4 mm · 1 mm · 1 mm

...EDERSCHLAG

WETTERPHONE 0450 199 1566

Gesamtösterreich +00 • Bundesländer: +01 Wien +02 NÖ/+03 B/+04 OÖ/+05 S/+06 K/+07 Stkm/+08 T/+09 V
5-Tage +10 • Segel +11 • Berg +12 • Schnee +13
Meer +14 • Europa +15 • Agrar +16 • Bio +17
KOSTEN: ...

Krone Wetter

TAGESWERTE

DIENSTAG, 10. JUNI 1997

In Österreich herrscht Hochdruckeinfluß. Meist scheint den ganzen Tag über ungetrübt die Sonne. Es weht schwacher Wind aus nördlicher Richtung. Sommerliches Temperaturniveau.

ÖSTERREICH

Wien	heiter	16/27
Eisenstadt	heiter	17/28
St. Pölten	heiter	16/27
Linz	heiter	11/25
Salzburg	heiter	12/26
Graz	heiter	13/26
Klagenfurt	heiter	13/25
Innsbruck	heiter	13/29
Bregenz	heiter	14/28

EUROPA

Amsterdam	heiter	21
Berlin	heiter	23
Brüssel	wolkig	22
Budapest	heiter	26
Istanbul	st. bew.	21
London	wolkig	19
Paris	wolkig	23
Prag	wolkenlos	25
Rom	heiter	28
Zürich	heiter	27

BIOWETTER

Der Hochdruckeinfluß bringt einige Unpäßlichkeiten. Es kommt in Ballungszonen zu erheblichen Wärmebelastungen. Herz- Kreislaufpatienten sollten sich unbedingt schonen. Sonst besteht kein den Organismus belastender Wettereinfluß.

VIERTAGEVORSCHAU

MI 16 28 · DO 16 27 · FR 15 25 · SA 15 23

Temperaturen (Tiefstwerte/Höchstwerte)

BERGWETTER

Hochdruckeinfluß bewirkt im Alpenraum gutes Berg- und Wanderwetter. Es weht mäßiger Wind aus nördlicher Richtung. Nur am Nachmittag harmlose Quellwolken.

WETTERPHON 0450 199 1566 00 max. öS 8,-/Min.

Eine Kaltfront vert... sommerlichen Gef...

Regenschauer wechseln mit nur kur...

Wetterlage: Der Zustrom kühler und feuchter Atlantikluft gegen die Alpen hält an.

Aussichten: Von Nordwesten ziehen Wolken und Regenschauer über unser Land. Besonders am Nordrand der Berge kann es stärker regnen. In ... und im Alpen... kommt zumindest ... die Sonne her... Temperaturen ... sehr sommer... Frühwerten zwi... 14 und Maxim... 19 Grad.

... durch... ürbare ... t, was ... atischen ... führt und Belastung und den ... utet. Das ist gestei... bringt meist gut...

VORSCHAU: Unter Hochdruckeinfluß gibt es kaum wetterbedingte Belastungen für den Organismus, wenngleich die Kältereize noch etwas erhöht bleiben.

Antalya	27/35	heiter	Las Palmas	17/23	wolkig	Prag	12/18	Regen
Athen	24/29	heiter	Lissabon	14/23	heiter	Rio de Jan.	21/30	heiter
Bangkok	25/32	Gewitter	London	10/16	heiter	Rom	18/24	heiter
Berlin	13/15	Regen	Los Angeles	18/26	wolkig	Stockholm	14/16	st. bewölkt
Brüssel	11/16	wolkig	Madrid	10/24	heiter	Sydney	9/17	heiter
Budapest	15/21	st. bewölkt	Mallorca	20/21	heiter	Tel Aviv	23/29	wolkig

MOND

abnehmend

BERGWETTER

-3 · -4/-2 3000 m · 3/6 · 2/5 1500 m · 8/15 · 9/18

Eine lebhafte Nordwestströmung bringt Wolken und Schauer. Schnee oberhalb 1800 m.

10/15

4-TAGE-VORSCHAU

Mittwoch	Donnerstag	Freitag	Samstag
13/20	14/24	15/21	15/19

Wettervorschau für Oberösterreich, Salzburg, Kärnten und Steiermark mit Angabe der Regenwahrscheinlichkeit in %

...AT vom 23.6.1997, 12:00 MESZ

THE PANNONIAN OZONE PROJECT

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The Pannonian Ozone Project (POP) has been a research campaign that yielded at the development of a photochemical simulation model for the analysis of ozone formation in north-eastern Austria. This region, where the Austrian capital Vienna is situated, suffers from high ozone peak values during the summer season, thus the project focused on this region at the border of the Pannonian Plain. The project has been funded by the Federal Ministries for Environment, Youth and Family Affairs, for Science and Transport, and for Agriculture and Forestry, and by the Federal Provinces of Vienna, Lower Austria and Burgenland.

The major objectives of the project were

- increased knowledge of ozone formation and transport around Vienna, especially a distinction between regional ozone formation in the plume of the agglomeration and the large-scale background concentration
- the simulation of the effects of emission reductions of the ozone precursors (nitrogen oxides/NOx and volatile organic compounds/VOC) on the regional ozone levels, in order to optimise future reduction plans for ozone precursors
- ozone forecasts for the next day

The scientific work was conducted in co-operation of the Federal Environment Agency (FEA), the Research Centre Seibersdorf and the Institute for Meteorology and Geophysics of the University Vienna.

The POP project comprised four major sub-projects

1. Development of the meteorological parts of the lagrangian photochemical model by the Institute for Meteorology and Geophysics
2. Establishing the emission inventory for NOx, VOC and CO by the Research Centre Seibersdorf
3. Establishing the photochemical model with meteorological and emission preprocessing units, the chemical reaction scheme (EuroRADM) and output routines, by the Research Centre Seibersdorf
4. The measurement campaigns in 1994 and 1995, co-ordinated by the Federal Environment Agency.

Within the project, a lagrangian photochemical model was developed. A box is being moved along a 96 hour back trajectory to it end-point in north-eastern Austria. The box comprises the planetary boundary layer up to the maximum mixing height that occurs during the 96 hour transport along the trajectory. Its diameter depends on the uncertainty of the trajectory and usually decreases during 96 hours; the final diameter is approx. 30 km. Vertical mixing of air within the box is modelled by splitting the box in several layers with turbulent exchange between them. The trajectories are being calculated with data from ECMWF; over Austria, national ground based wind measurements are used to improve the accuracy of the trajectory.

Meteorological data from ECMWF, radiosonde measurements, synoptic stations and - over Austria - from the dense national meteorological monitoring network are used for the calculation of the mixing height and as input for the chemical module. The chemical reactions are modelled by the EuroRADM scheme.

Emission inventories have been established for NOx, VOC and CO. For Austria, the Czech Republic, Slovakia and Hungary, a highly resolved emission inventory on a grid of 5 km has been elaborated. The basic emission data have been provided by the Austrian Federal Environment Agency, the Hungarian Institute for Environment Management, and for the Czech Republic and Slovakia from the REZZO inventory. For the other parts of Europe, the CORINAIR 90 and the EMEP inventory have been used to calculate emissions on the 50 km EMEP grid in western Europe (EC countries) and the 150 km grid in eastern Europe.

Model results are not yet available since the final report of the project has not yet been finished.

For the validation of the model, measurement campaigns were conducted in summer 1994 and 1995 to yield data on the three dimensional distribution of ozone and its precursors NOx and VOC, other photochemical pollutants (Peroxiacetylnitrat/PAN and H_2O_2) and a multitude of meteorological parameters.

The measurement campaign comprised

- Continuous measurments of ozone and NO/NO_2, wind direction and velocity, air temperature and other meteorological parameters at the sites of the Air Quality Monitoring Network of the Federal Provinces of Vienna, Lower Austria and Burgenland
- Continuous monitoring of NO_2 (selective), CO, PAN, H_2O_2 and Non-Methane Hydrocarbons (NMHC) in Illmitz
- Continuous monitoring of NMHC at Exelberg during July and August
- Measurements of ozone, NO_2, NMHC, H_2O_2, wind direction and velocity, temperature and humidity by two (manned) aeroplanes on 13 days in July and August
- Sampling (and further laboratory analyses) of aldehydes and ketones, sulphur and nitrogen compounds, and NMHC at five sites in Eastern Austria (Illmitz in Burgenland, Exelberg, Unterbergern im Dunkelsteinerwald, Himberg and Stixneusiedl in Lower Austria) on selected days
- Vertical profiles of ozone, temperature and humidity by model aeroplanes at selected sites - mainly Unterbergern im Dunkelsteinerwald - on selected days
- Vertical profiles of ozone, wind direction and velocity, temperature and humidity by a tethered balloon in Illmitz on selected days
- Vertical wind profiles by SODAR in Illmitz and Vienna/Leopoldau
- Tracking of small-scale trajectories by tetroons

The measurement campaign focused on warm, sunny days in July and the first half of August 1995 when high ozone concentrations were expected. Aeroplane measurements were conducted on July 20 - 22, July 26 - 27, August 1 - 2, August 6 - 7, and August 11 - 14.

This presentation focuses on the aeroplane measurements and budget calculations for ozone and NO_2 which were conducted by M. Lehning.

Aeroplane equipment and flight pattern

Two motor gliders (type Stemme S10) from the Swiss company MetAir were engaged on contract of the Federal Environment Agency.

The table gives the monitoring equipment of the two aeroplanes:

Aeroplane 1		Aeroplane 2	
Ozone	UV-absorption (ML8810 modified by Paul Scherrer Institute)	Ozone	UV-absorption (ML8810 modified by Paul Scherrer Institute)
NO_2	Luminol chemiluminesence (Scintrex/Unisearch)	NO_2	Luminol chemiluminesence (Scintrex/Unisearch)
		H_2O_2	Fluorescence with Peroxidase (Aero-Laser)
NMHC	Gas chromatography (Airmotec HC1010)	NMHC + CO	Sampling by evacuated steel cans, analyses by Fraunhofer Institute, Garmisch-Partenkirchen
Wind direction, velocity, temperature, relative humidity			

The gaschromatograph used in the aeroplane - as well as in Illmitz and Exelberg - yielded carbon compounds from C4 to C10, the can analyses alkanes from C2 to C8, alkenes from C2 to C5, alkines from C2 to C3, cycloalkanes from C5 to C6, benzene, toluene and isoprene, and additionally CO.

The aeroplanes were stationed in Wiener Neustadt (50 km south of Vienna). Flights were conducted before noon (about 9:00 to 12:00) and in the afternoon (about 14:00 to 17:00).

The flight pattern of aeroplane 1 followed a hexagonal path around Vienna at a distance of 20 to 60 km at a height of some 100 m above ground level. Before noon, the rise of the mixing layer could be observed. The flight tracks was extended up to 100 km leeward of Vienna in case the plume reached such a distance.

Aeroplane 2 followed the hexagonal track of aeroplane 1 once per flight and observed vertical profiles from ground level up to the free troposphere above the mixing layer.

The results mainly confirmed the knowledge about ozone concentration levels, transport and formation around Vienna that was gained by ground-based monitoring during the last years, but gave a multitude of additional information on horizontal and vertical transport of ozone and its precursors, especially in the plumes of Vienna and Bratislava.

OZONE FORECAST IN AUSTRIA

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Abstract

High ozone peak concentrations in parts of Austria during summer draw public interest not only on short-term information of high ozone levels, but also on the forecast of peak concentrations for the next day.

The Austrian Ozone Act (1992) which regulates measurement of and information to the public about ozone levels requires ozone forecasts by the nine Federal Provinces of Austria. These forecasts are given as coarse verbal information („Rising", „Falling") and are based on various meteorological observation and forecast data provided by the Central Institute for Meteorology and Geophysics.

In recent years, the Federal Environment Agency (FEA) has undertaken efforts to establish ozone forecasts on a national level based on scientific knowledge and mathematical models. Three models have been developed, the first of which has been tested and implemented to operational use last year.

1. In contract and in close co-operation with FEA, the Research Centre Seibersdorf developed a linear regression model, that uses statistical relations between peak ozone concentrations and maximum temperatures of „today" and „tomorrow". A regression function has been developed for about 50 monitoring sites in Austria. The forecast temperature is provided by the Central Institute for Meteorology and Geophysics. The calculated results for each monitoring site are being interpolated to a map by a sophisticated procedure developed by the Research Centre Seibersdorf some years ago. This ozone forecast model yields good results for „mean" concentration levels, but forecast skill is rather poor for extreme (high) concentrations which cannot be models adequately by statistical relations.
2. In summer 1997, an ozone forecast model based upon „artificial neuronal networks" will be tested by the FEA for ten ozone monitoring sites. Artificial neuronal networks imitate functions of biological neurones and can model complex non-linear relations in cases where analytical functions cannot be developed. Input parameters are time series of ozone and primary pollutants (e.g. NO, NO_2, CO), various meteorological parameters (wind speed and velocity, temperature, humidity, solar irradiation) and forecast temperature.. These input parameters will be available nearly on-line from the respective air quality monitoring stations and from the Central Institute for Meteorology and Geophysics.
3. The most „scientific" approach towards ozone forecast is the use of a photochemical simulation model, which has been developed within the „Pannonian Ozone Project" (POP). This langrangian model yields forecast ozone concentrations at five sites in north-eastern Austria. In comparison to the above-mentioned models, the langrangian photochemical model requires a large computer and much more CPU time. The ozone forecast by this model will be tested in summer 1997 and will give complementary information to the linear regression model.

AMETIS 2
SYSTEM FOR THE FULLY-AUTOMATIC GENERATION OF METAR REPORTS AT ZURICH AIRPORT

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ABSTRACT

In the time between midnight and 0500 local time night flight restrictions forbid landings or take-offs at the airport of Zurich. Nevertheless a weather report (METAR) has to be generated by human observers every half hour during the night.

To reduce the charge of night services of human observers and to enforce the meteorological services during daytime, the project AMETIS 2 (AMETIS = Aeronautical METeorological Information System) was initiated in 1991. The aim of this project is the fully-automatic generation of METAR reports during hours with poor air traffic, during daytime the system assists the human observers.

The AMETIS 2 system is installed at Zurich-Kloten airport. In case this pilot system fulfills the expectations, the airport of Geneva and other airports in Switzerland will be equipped in the same way. With the fully-automatic generation of weather observations the quality will slightly decrease, nevertheless this should have no influence on the flight safety.

The system AMETIS 2 system collects datas from conventional instruments which where already installed at the airport and from new sensors, which has been purchased especially for this project. These new sensors have been tested during a period of about two years, so the properties of them are well-known.

The system hardware consists of SUN-computers and components. UNIX V.R4 is used as operational system software. To achieve a high availability, the system is fully redundant (active system and stand-by system). The two systems perform the same tasks in parallel and maintain their own data storage. In case of failures a switchover is done automatically without any human intervention.

The AMETIS 2 system generates every 60 seconds a METAR report which is displayed only locally. Every 30 minutes (HH+18', HH+48') a report is sent to the global telecommunication system. The reports which are generated every 60 seconds pass a checker; if defined threshold values are reached or passed, a special report is issued. The human observer has the possibility (interactive) to control all generated values and change them if necessary.

The computer system is composed of several processing modules. Each meteorological parameter included in the final message is processed independently from the others. Of all the modules AMETIS2 has to deliver, some are straight-forward to automate, such as identification, wind, temperature/dew point and pressure. Other modules like visibility/runway visual range and CAVOK demand an additional treatment. Because subjective estimates of weather characteristics cannot be directly measured by an instrument, the modules present weather and clouds are very pretentious.

The project group developed a collection of rules, which are used by the system to generate the present weather module. These rules are a first approach and there is fine tuning during the development of the system. In these rules different decision trees and checks are included. It is not possible to generate all

code figures following to the METAR-Code of WMO.

The cloud module was realized in collaboration with the Centre for Neuromimetic Systems of the Swiss Federal Institute od Technology in Lausanne (EPFL). The project was sponsored by the Swiss National Science Foundation. The aim envisaged with the project was the generation of the cloud module with the help of artificial intelligence and neuronal networks (project-name MANTRA = Machine Neuronale en TRAnches).

The originality of the work is the use of a long-wave radiometer, a pyrgeometer, to estimate the cloud amounts, whose processing is performed by an artificial neural network instead of empirical rules. Laser ceilometers are used to extract the bases of cloud layers by means of a heuristic processing. Results of this module show that information automatically produced by the module can be used as a good estimate of the clouds in a completely automatic METAR generator.

For the generation of the clouds module a preprocessing of the ceilometer datas is applied. An algorithm is introduced to filter the cases where either the sky is clear, or only one complete layer is present (overcast). Otherwise, if the filter classifies the situation as difficult, the heights of the clouds bases are determined and sent to the ANN module which assigns a cloud amount to each detected layer. Finally a simple postprocessing ensures the consistency of the module's output with respect to the METAR format.

The preprocessing of ceilometer data is first aimed at filtering easy cases, namely sky-clear and sky-overcast by one layer. The goal of this filter is to produce early diagnosis with great accuracy without passing through sophisticated algorithms which may reduce the quality of the result. This is achieved by asking for a high level of correctness when defining the set of heuristic criteria. For non-easy cases, a clustering routine is developed to determine the number and the heights of the cloud layers present in the sky at observation time. Filtering of easy cases is achieved using heuristic rules based on the maximum range of detection, the relative emittance and on the values of the ceilometer histogram. For cases not labeled as easy by the preceding step, the neuronal network is used to estimate the corresponding cloud amounts.

A back-up cloud module (CEILO), which bases only on the datas of the ceilometers, was created additionally.

The project started in 1991 (primary studies, provisional technical specifications). From 1993 until 1995 new sensors were tested. In 1995 a first prototype was realized and the clouds module MANTRA was integrated in this prototype, in 1996 most of the modules were realized. In September of this year the system will be started up. In Winter 1997/98 the AUTO-METAR will be compared with conventional METAR observations.

The system will be operational in Spring 1998.

A one-dimension operational *nowcasting* model for Germany

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As a matter of fact, effectiv *Nowcasting* presumes short time access to meteorological parameters, their analysis and a very short range monitoring up to two hours. This heuristical and empirical *Nowcasting Model NM* consists of numerous modules focused to hazardous weather events such as Cb/Ts, precipitation, hail and so on (see W. Wehry, *A 1-Dimensional Model for Nowcasting of Hazardous Weather Events*, this Volume). COST78 action plan inspired this technique and development. Based on the model output of DWD *Deutschland Modell DM*, we implemeted the horizontal grid pattern 109x109 in dimension. Because of neglecting $\sigma-$ or p - levels, down or upward motions are parameterized by computed particular parameters (*Totals Totals Index*). Meteorological parameters of various platforms, e.g. SYNOPS, TEMPS, radar and satellite data (METEOSAT) are involved. Cloudtop temperatures are derived by DMO and METEOSAT data. Each module may be processed separately, but intersection within the model is considered. With regard to intensiv data initialization and assimilation routines CPU processing time was minimized effectively. An exemplary figure (1) demonstrates a processed warning module for Cb/Ts at time t=t+0 [h].

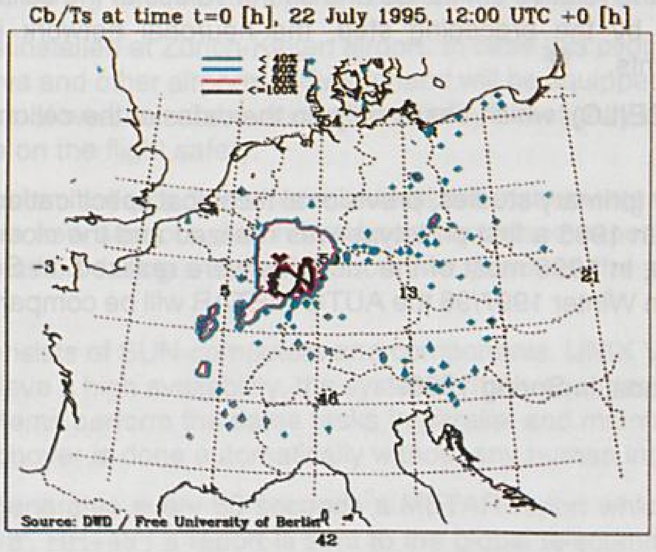

Figure 1: Cb/Ts warning *actual hour* at time t=t+0 [h]; (22 July 1995, 12:00 UTC)

Figure (2) presents the *nowcasted* information of a warning event at time t=t+1 [h] as one superposition of METEOSAT image with slot number 24 and the available Totals Totals Index deduced of DMO data at time t=t+0 [h]. The extrapolation of an additional timestep to t=t+2 [h] will be seen in figure (3), but an operational implementation is not yet tested.

First case studies to particular modules provide important settings for application. Anyway a verification phase to a one year time section must be carried out before this model will become operational. The modular topology and results of one case study to the Cb/Ts module will be presented.

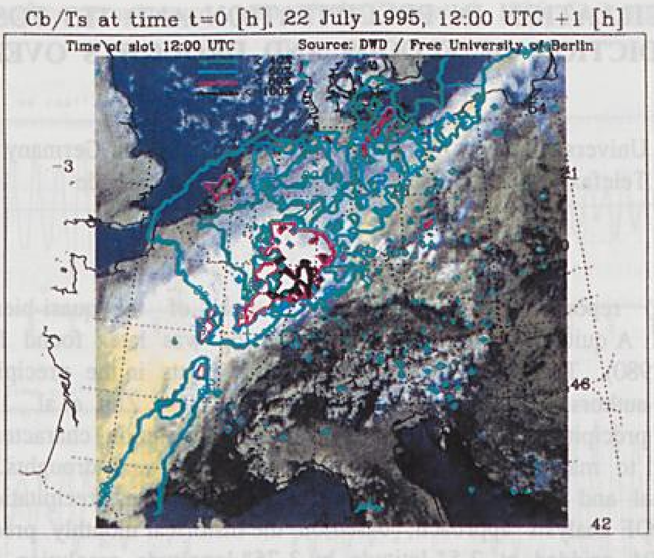

Figure 2: Cb/Ts warning at time t=t+1 [h]; (22 July 1995, 12:00 UTC)

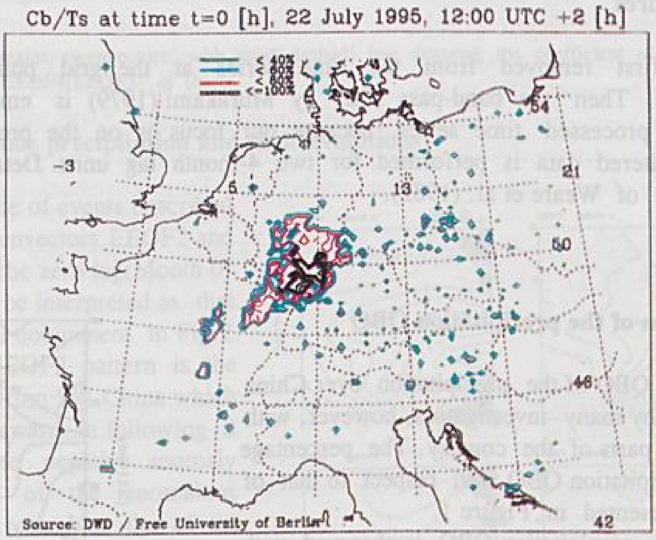

Figure 3: Cb/Ts warning at time t=t+2 [h]; (22 July 1995, 12:00 UTC)

Literature:

DWD , 1995. *Herbstschule Radarmeteorologie 1995 (23. Oktober bis 31. Oktober 1995).* Annalen der Meteorologie, Deutscher Wetterdienst Offenbach, Selbstverlag, Band 32, 239 Pages. ISSN 0072-4122.

Edelmann W., Majewski D.,1993. *Die Datenbanken des Deutschland-Modells auf der Cray Y-MP und der MFB (MFA) des DWD.* Technical Report, Deutscher Wetterdienst DWD, Offenbach, 63 Pages.

ESA ,1984. *Nowcasting II: Mesoscale observations and very-short-range weather forecasting.* Proceedings of the 2nd International Symposium on Nowcasting, Norrköping, Sweden. 3-7 September 1984. European Space Agency, ESA SP-208, Paris CEDEX.

Pelz J., 1984. *Die geographische Verteilung der Tage mit Gewitter in Mitteleuropa*, Beilage zur Berliner Wetterkarte, Institut für Meteorologie der Freien Universität Berlin, SO 12/84, 48/84, Berlin. 12 Pages.

Purdom J., 1997. *Nowcasting with the new generation GOES*, Advanced Space Research, Volume 19, No. 3. Pergamon Press, pp 423-432.

QUASI-BIENNIAL OSCILLATION IN PRECIPITATION AND ITS POSSIBLE APPLICATION TO LONGTERM PREDICTION OF FLOODS AND DROUGHTS OVER EASTERN CHINA

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1. Introduction

Jagannathan et al. (1973) reported a dominant spectral peak of the quasi-biennial oscillation (QBO) in the Indian monsoon rainfall. A quite notable quasi-biennial period was later found for the precipitation over the United States (Walsh et al.,1980). The fact that an evident QBO exists in the precipitation over China has been revealed by many Chinese authors (e.g. Wang et al.,1981; Huang, 1988; Zhu et al., 1991). However, the spatial distribution features of the precipitation QBO and its temporal evolution characteristics are still of interest, especially when we attempt to make a longterm prediction of floods and droughts.

In this paper the spatial and temporal features of the QBO in the precipitation over eastern China are investigated in terms of EEOF analysis approach, based on the historical monthly precipitation dataset for global land areas from 1900 to 1994, gridded at 2.5° latitude by 3.75° longitude resolution which has been constructed and supplied by Mike Hulme at University of East Anglia, UK.

2. Computational procedures

The annual cycle is first removed from the time series at the grid points that cover the area of 105°E-120°E, 22.5°N-40°N. Then the band-pass filter by Murakami (1979) is employed for a 24-36 month filtering of the previously processed time series, because our focus is on the precipitation QBO. The EEOF analysis of the band-pass filtered data is performed for two 4-month lag units. Details about the EEOF method are described in the article of Weare et al. (1982).

3. Results

3.1 Geographic distribution of the precipitation QBO

As mentioned above, the QBO of the precipitation over China was found to be appreciable by many investigators, however, with different impact on different parts of the country. The percentage of the variance of the precipitation QBO with respect to that of interannual variations is presented in Figure 1.

Figure 1 shows that the precipitation QBO is observed with more than 20% of the variance of interannual variations on the NE side of the Qinghai-Tibetan Plateau where the annual precipitation amount is relatively small compared to that over southern China, in the basin of Yangtse River, in Guangxi and Fujian Provinces and their vicinity, indicating that QBO is of great importance in these areas. These findings agree reasonably well with observations of others (Xu et al., 1982; Bai et al., 1988).

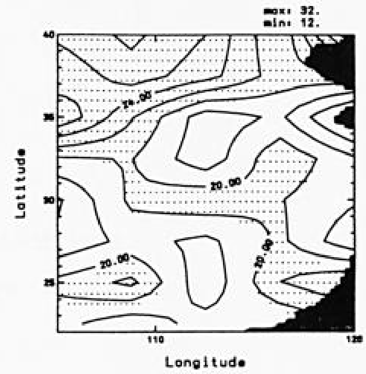

Fig. 1 The percentage of variance of QBO with respect to that of interannual variations. Regions of more than 20% are shaded.

3.2 Quasi-biennial and interdecadal variations of principal components

The first four eigenvectors are significantly distinguished from those resulting from sampling fluctuations using the statistical test of rule-of-thumb by North et al.(1982). They account for 18.4%, 13.1%, 11.2% and 7.9%, respectively, of the total variance.

Figure 2 shows the principal components associated with the first four EEOFs for the period from January 1902 to April 1994. It is apparent that a 24-36 month quasi-periodic variation is present in these time series. Also evident is the large interdecadal variability of these time series, indicating that the QBO is modulated by interdecadal variations. Spectrum analysis results using the singular spectrum analysis(SSA) approach by Vautard et al.(1989) show that 40-50 year and 20-25 year periods are pronounced in the principal components associated with EEOF1,2 and EEOF3,4, respectively.These two kinds of quasi-periodic oscillations are also found in the ocean-atmosphere interactions and the global surface temperature, respectively(Chen et al.,1996; Ghil et al., 1991).

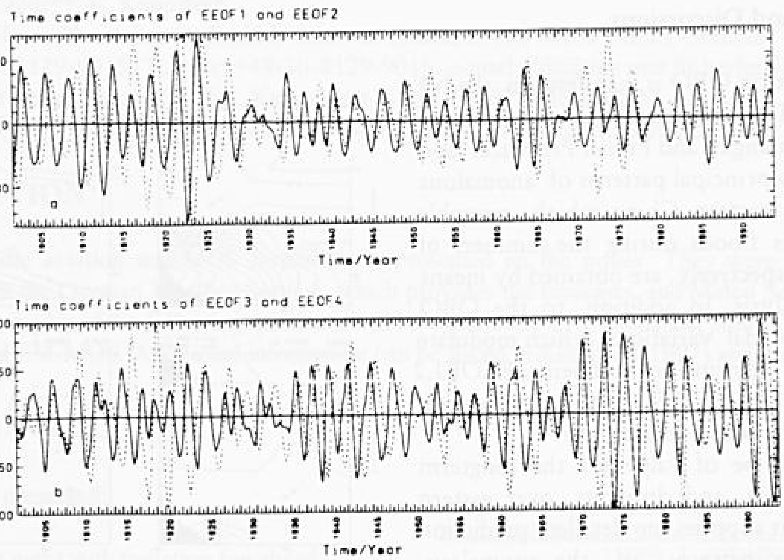

Fig. 2 Time coefficients of four major eigenvectors, with solid(dashed) line denoting the coefficient of EEOF2(EEOF1) in (a); and solid(dashed) line for EEOF4(EEOF3) in (b).

3.3 Patterns of the anomalous precipitation and their evolutions

Figure 3 depicts a sequence of events described by the first two extended eigenvectors,EEOF2 and EEOF1. The actual phase of the zero lag(Month 0) pattern in the EEOF should be interpreted as that of the corresponding principal component in Fig.2. One obvious feature of the EEOF2 pattern is the negative anomaly originating from SW China which develops and extends northeastward in following 8 months and merges with the negative anomaly in East China. This pattern of the anomalous precipitation and its evolution resembles that of the disastrous floods taking place in some parts of southern and eastern China during the summer of 1996. The time coefficient of EEOF2 in the winter of 1995 can be extrapolated with its quasi-biennial periodicity and turns to be negative.The contribution of EEOF2 to the actual precipitation anomaly in the above mentioned area for the summer of 1996 is a positive anomaly.

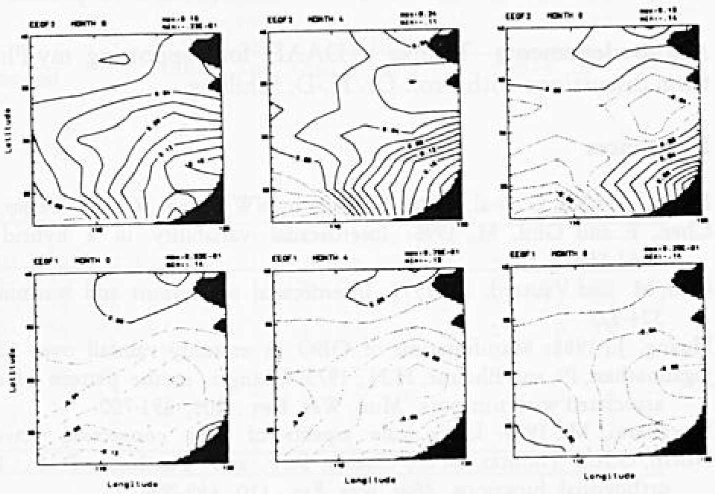

Fig. 3 Space-time structure of EEOF1 and EEOF2, with solid(dashed) line denoting positive(negative) value.

Because of the orthogonality of eigenvectors, the panel of 8-month lagged EEOF2(EEOF1) shows a basically similar space structure of anomalies to that of zero-month lagged EEOF1(EEOF2), but with the reversal of signs for the latter case. As a consequence,the patterns of EEOF1 and EEOF2 describe nothing but the space structures of anomalies of different time phases for the same quasi-biennial period, with EEOF2 a quarter of the period in phase ahead of EEOF1. The sequence of events depicted by EEOF1 demonstrates a southeastward propagation of anomalies. The evolution of anomalies for the second half period shows that the reverse anomalies develop and propagate in the same way as for the first half period.

As shown in Figure 4, the patterns of anomalous precipitation illustrated by EEOF4 and EEOF3 describe a negative anomaly developing between Yangtse River and Huaihe River and then extending southwestward within 4 months. Anomalies subsequently propagate southward in the following quarter period. It should be noted that the pattern of 4-month lagged EEOF4 is quite similar to that of the disastrous floods in East China during the summer of 1991, with a negative time coefficient of EEOF4 four months before considered.

4. Conclusions and Discussions

The precipitation QBO is manifest on the NE side of Qinghai-Tibetan Plateau, in the basin of Yangtse River, Guangxi and Fujian Provinces and their vicinity. Two principal patterns of anomalous precipitation over eastern China which resemble those of disastrous floods during the summers of 1991 and 1996, respectively, are obtained by means of the EEOF analysis. In addition to the QBO, we found interdecadal variations which modulate the QBO in the principal components, EEOF1,2 by a 40-50 year and EEOF3,4 by a 20-25 year quasi-periodic variations, respectively.

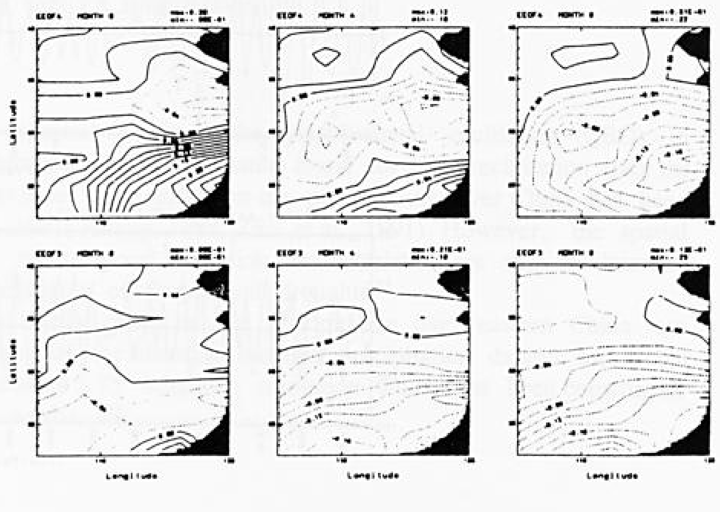

Fig. 4 As in Fig. 3 but for EEOF3 and EEOF4

Our result may be of value for the longterm prediction of floods and droughts over eastern China. However, it supplies no detailed prediction, but the possible patterns of the anomalous precipitation and their evolution within a 24-36 month period. In fact, disastrous floods have been frequently observed over eastern China in recent years. Some were the century's or even past 500 years' worst. From the historical monthly precipitation dataset it is difficult to predict statistically the magnitude of floods. However, the principal patterns of floods and droughts are relatively stable, hence can be used to predict the local distribution of floods and droughts.

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References

Bai, Z. and Xu, G. et al., 1988: Weather in NW China. *China Meteor. Press*, 161pp. (in Chinese).

Chen, F. and Ghil, M., 1996: Interdecadal variability in a hybrid coupled ocean-atmosphere model. *J. Phys. Oceano.*, **26**, 1561-1590.

Ghil, M. and Vautard, R., 1991: Interdecadal oscillations and warming trend in global temperature time series.. *Nature*, **350**, 324-327.

Huang, J., 1988: Manifestation of QBO in monthly rainfall over China. *Atmos.. Sci. Sin.*, **12**, 267-273 (in Chinese).

Jagannathan, P., and Bhalme, H.N., 1973: Changes in the pattern of distribution of southwest monsoon rainfall over India associated with sunspots. Mon. Wea. Rev., 101, 691-700.

Murakami, M., 1979: Large scale aspects of deep convection activity over Gate area. *Mon. Wea. Rev.*, 107, 994-1013.

North, G.R., Thomas, B. L., Chalan, R. F. and Fanthune, J. M., 1982: Sampling errors in the estimation of empirical orthogonal functions. *Mon. Wea. Rev.*, **110**, 699-706.

Vautard, R. and Ghil, M., 1989: Singular spectrum analysis in nonlinear dynamics, with applications to paleoclimatic time series. *Physica D*, **35**, 395-424.

Walsh, J.E. and Mostek, A., 1980: A qualitative analysis of meteorological anomaly patterns over the United States, 1900-1977. *Mon. Wea. Rev.*, **108**, 615-630.

Wang, S. and Zhao, Z., 1981: Climate and History, *Cambridge Press.*

Weare, B.C. and Nasstrom, J. S., 1982: Examples of extended empirical orthogonal function analysis. *Mon. Wea. Rev.*, **110**, 481-485.

Xu, G. and Dong, A., 1982: Quasi-triennial periodicity in precipitation over western China. *Plateau Meteorology*, **1**, 11-16 (in Chinese).

Zhu, Q. and Zhi, X., 1991: Quasi-biennial oscillation in rainfall over China. *Acta Meteor. Sin.*, **5**, 426-434.

AUTOMATIC REAL TIME AVIATION AND MOS FORECASTS

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1. INTRODUCTION

Operational automatic aviation and MOS forecasts are presented on the poster. They were developed in close cooperation between the German Weather Service, which provides the forecasts, and Meteo Service. In this paper historical forecast examples of the following products will be explained: TAF-guidance, Auto-TAF, Auto-GAFOR, Grid-Point MOS and EM-MOS. Additional information can be found in Knüpffer (1997) and Richter (1997).

2. TAF-GUIDANCE

Three examples are presented:

Table 1a: Autumn, a night with radiation fog ahead. High probabilities for the rare event of 'Vis<400m' are forecast, e.g. 50% at 21z, to be compared with a climatological expectance of about 0.8% for this event in late October (cf. Table 1b).

Table 1b: Autumn, dull day with low ceiling.

Table 1c (next page): Late spring, thunderstorms and gusts possible in the afternoon.

TAF-Guidance, Ausgabe Mi, 23.10.96, 18.13z
St 10382 Berlin Tegel 52:34 N 13:19 E 37 m

	OBS	VORHERSAGEN MOS				
PREDICTAND	16z	18z	21z	00z	03z	06z
DD	36	2	5	7	9	9
FF /kt	3	3	3	3	2	3
VIS / 100m	40	25	17	30	12	14
P_Vis< 8 km	100	78	74	74	77	72
P_Vis< 5 km	100	70	71	61	64	64
P_Vis< 3 km	0	57	59	46	60	64
P_Vis<1.5km	0	34	50	45	60	51
P_Vis<800m	0	34	50	45	49	39
P_Vis<400m	0	11	50	45	32	34
P_Vis<200m	0	8	6	1	11	11

Table 1a: Explanation cf. Table 1b

TAF-Guidance, Ausgabe Mo, 21.10.96, 10.41z St 10384 Berlin Tempelhof 52:28 N 13:24 E 46 m

	OBS	VORHERSAGEN MOS									KLIMA 1/92 - 3/96							
PREDICTAND	10z	12z	15z	18z	21z	00z	03z	06z	09z	12z	21z	00z	03z	06z	09z	12z	15z	18z
VIS / 100m	28	48	57	48	44	41	33	25	26	44	OK	OK	OK	74	79	OK	OK	OK
P_Vis< 8 km	100	71	66	69	72	70	75	76	80	72	25	29	34	43	39	29	23	22
P_Vis< 5 km	100	52	46	53	51	51	55	63	64	52	16	19	23	31	25	18	14	25
P_Vis< 3 km	100	31	27	27	35	37	41	45	45	35	9	12	16	21	15	10	8	8
P_Vis<1.5km	0	13	14	16	17	22	28	28	26	16	5	7	10	13	8	4	4	4
P_Vis<800m	0	0	5	6	8	9	12	12	9	3	2	4	5	7	3	.9	.8	2
P_Vis<400m	0	0	5	6	8	9	7	8	2	1	.8	2	3	5	2	.2	.2	1
P_Vis<200m	0	0	5	3	8	7	5	5	1	1	.6	1	2	2	.4	0	0	.2
N	8	8	7	8	7	7	7	8	8	8	4	5	4	5	5	5	5	4
Okta<5000ft	8	7	6	6	7	7	7	8	8	8	3	3	3	3	3	4	4	3
Okta<1500ft	8	7	5	4	4	4	4	4	5	4	1	1	2	2	2	1	1	1
Okta<1000ft	8	7	5	4	4	4	3	3	4	3	.7	1	1	1	1	1	1	1
Okta< 500ft	8	6	3	3	2	2	2	2	2	2	.4	.5	.7	.9	.7	.4	.3	.4
Okta< 200ft	0	0	0	0	0	0	0	0	1	0	.2	.2	.3	.6	.3	0	0	.1
P_BKN<5000ft	100	92	84	73	92	89	88	86	89	94	32	38	39	43	42	43	38	30
P_BKN<1500ft	100	92	79	67	62	59	45	50	63	44	13	16	20	22	20	16	14	12
P_BKN<1000ft	100	91	77	62	62	59	39	41	57	40	8	12	16	17	16	12	10	8
P_BKN< 500ft	100	91	44	39	35	31	21	27	32	20	5	5	8	11	8	5	4	4
P_BKN< 200ft	0	0	1	0	0	1	2	3	8	2	2	2	4	8	3	.7	1	1
Ceiling /hft		4	6	7	8	8	18	15	9	19	OK	OK	OK	OK	OK	OK	OK	OK
P_OVC<5000ft	100	71	56	66	71	73	79	56	69	70	18	20	22	23	22	18	16	16
P_OVC<1500ft	100	67	54	54	48	47	32	27	45	31	7	10	13	13	11	8	6	6
P_OVC<1000ft	100	67	44	49	48	46	26	26	41	27	6	8	9	12	10	7	5	5
P_OVC< 500ft	100	67	44	29	23	27	21	26	24	15	3	4	6	9	5	3	3	3
P_OVC< 200ft	0	0	1	0	0	0	2	3	8	0	1	1	3	6	3	.4	.6	1
Overcast /hft		4	13	11	16	17	30	45	21	32	OK	OK	OK	OK	OK	OK	OK	OK

Table 1b: TAF-guidance. From Left to Right: Predictand Name (' P_' means 'Prob of'), Last Observation, Forecasts, Climatological Expectance of the Predictands for the 21st October

3. ENCODED TAF

The MOS matrix output of the TAF guidance is encoded into a TAF complying with WMO and ICAO regulations. The example refering to Table 1c is:

EDDF 271019 24010KT 9999 SCT045 TEMPO 1019 25015G25KT 1500 TSRA SCT010CB

TAF-Guidance, Ausgabe Mo 27.05.96, 09.13z
St 10637 Frankfurt/M 50:03 N 08:36 E 111m

	OBS	VORHERSAGEN MOS				
PREDIKTAND	08z	09z	12z	15z	18z	21z
DD	22	22	23	25	25	29
FF /kt	10	11	10	10	9	7
FF_MAX_GUST		17	20	26	23	18
P_MAX_GST>25	0	12	29	52	38	17
P_MAX_GST>40	0	0	1	5	2	0
Tl /C	13	14	15	16	14	13
Td	13	12	11	11	11	12
P_ww_STRATIF	0	23	14	5	2	11
P_ww_SHOWER	0	5	16	30	30	11
P_Cb %	0	2	11	39	36	10
P_ww_THSTORM	0	0	2	17	15	1
P_ww_REC_VCY	0	9	24	23	19	16
P_ANY_PRCPTN	0	28	30	35	32	22
P_ww_LIQUID	0	28	30	35	32	21
P_ww_FREZING	0	0	0	0	0	0
P_ww_SOLID	0	0	0	0	0	1
RR/6hr mm/10			11		10	
P_RR/6h>.1mm			69		65	
P_RR/6h>5 mm			12		11	
N	7	7	6	6	4	4
Okta<5000ft	5	5	5	3	1	1
Okta<1500ft	1	1	1	0	0	1
P_BKN<5000ft	100	55	20	0	0	0
P_BKN<1500ft	0	0	2	0	0	0
Ceiling		45	OK	OK	OK	OK

Table 1c: Explanation cf. Table 1b

4. AUTO-GAFOR

Table 2 shows the Auto-GAFOR for the example presented in Table 1b for the area in which the airport Berlin Tegel is situated. The Index (PREVAILING(50%)) shows the change of the expected flight conditions from "Charlie" to "Mike". VARIABLE(30%) indicates that there is a chance of more than 30% even for X-Ray conditions. The Visibility and Ceiling columns show, it is not the ceiling but the visibility that causes the obstructions. This is typical of radiation fog situations.

Issued	GA		Visibility					Ceiling					Index				
			OBS	1	2	3	T	OBS	1	2	3	T	OBS	1	2	3	T
96102318	8	PREVAILING(50%)	C	D	D	M	M	C	C	C	C	C	C	D3	D3	M6	M6
96102318	8	VARIABLE__(30%)	D	D	X	X	X	C	C	C	C	C	D3	D3	X	X	X
96102318	8	MINIMUM__(50%)	D	D	M	M	M	C	C	C	C	C	D3	D3	M6	M6	M6

Table 2: Auto-GAFOR Refering to the TAF Guidance Example in Table 1b

5. GRID-POINT MOS

Probabilities of Thunderstorms are forecast in three categories:

ISOL : At least 1 Ths in radius
OCNL: >50% of Observations are Ths
FREQ: >75% of Observations are Ths

Table 3 shows the probabilities of isolated thunderstorms over Germany at EM grid points. Minima can be seen in the coastal areas and in the south-east, an area of maximum probabilities extends from the west to the north-east. The highest chances for isolated thunderstorms, however, are predicted for the Alps.

Probability of Isolated Thunderstorms
T+012 Valid time: Monday 20.07.92 18z

		4	5	3	1	5		1	5		
	1	1	1	0	4	1	10	0	3	2	
	1	1	2	3	4	5	10	26	19	23	
		6	4	12	3	24	11	17	16	20	
	2	10	13	9	8	21	26	12	6	11	2
	3	7	17	13	8	14	12	18	28	12	3
14	15	10	31	22	18	30	16	32	5	17	2
24	33	19	33	23	13	23	13	16	7	13	6
24	21	30	14	27	15	33	30	8	9	12	4
31	26	25	21	14	2	19	5	14	13	15	
29	29	14	4	8	10	3	5	13	10		
14	19	10	2	6	10	8	3	7	5	2	
17	6	19	11	11	31	13	5	2	2	1	
	17	26	35	44	15	15	18	1	1	4	
	29	31	45	63	31	36	23	9	3		
	12	20	24	35	49	44	9	2			

Table 3: Grid-Point MOS Example

6. EM-MOS

EM-MOS is a MOS system with predictands of general interest. Standard elements are forecast with two special features:

- MOS forecasts are Kalman-filtered, with empirically optimized adaption speed
- MOS forecast errors are predicted.

Operational application has shown that MOS forecasts are seldom changed by the Kalman Filter. Therefore, the Kalman Filter forecasts were omitted in the standard output list. Table 4 shows an example. Differences between DMO and MOS are high for dew point temperature (Td) at 00 and 06z and occasionally for cloud cover (N).

EMOS Vorhersagen vom Montag 02.06.97, Ausgabe 6.30z
Station 10379 Potsdam 52:23 N 13:04 E 81 m

	OBS	Mo 02		Di 03				Mi 04				Do 05		KLIMA 92-96			
PREDICTAND	06	12	18	00	06	12	18	00	06	12	18	00	06	12	18	00	06
Tmax /C	13		20		16		20		17		23		18		21		18
DMO		20	21	17	11	21	20	17	15	23	23	21	17				
AbsErr			1		1		1		1		2		2				
Tmin /C	6		8		7		9		9		12		12		12		11
DMO		11	17	8	6	11	17	10	9	15	21	13	11				
AbsErr			1		1		1		1		1		1				
Tl /C	8	19	16	9	10	18	16	11	13	21	18	13	15	19	18	13	12
DMO		20	17	8	11	20	17	10	15	23	21	13	17				
AbsErr		1	1	1	1	1	2	1	1	2	2	1	1				
Td /C	7	6	5	6	7	6	8	8	8	8	9	9	9	10	10	10	10
DMO		6	4	5	8	6	4	-2	2	6	3	-3	1				
AbsErr		1	1	1	1	2	2	1	1	2	2	2	1				
DD	3	5	3	5	36	35	34	18	27	28	32	14	18	28	31	27	27
AbsErr		2	1	2	3	3	4	5	4	4	5	5	6				
FF /kt	6	8	8	7	5	6	6	6	5	5	4	7	5	8	7	7	7
DMO		7	7	4	3	5	4	1	3	4	2	1	1				
AbsErr		1	1	2	2	2	2	2	2	2	2	2	2				
MAX_GUST/kt		15	16	13	10	11	12	10	9	9	8	13	10	16	16	14	13
DMO		19	17	16	12	12	13	11	9	11	11	5	5				
MAX_MEAN/kt		10	10	8	7	8	8	7	6	7	6	9	7	10	9	9	9
N	3	3	3	1	2	4	4	2	4	5	4	3	4	6	5	4	5
DMO		0	0	0	0	3	2	0	0	2	2	0	0				
AbsErr		2	2	1	2	2	2	2	2	2	2	2	3				
VIS / 100m	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
P_VIS<1000m	0	1	1	1	2	1	1	2	2	1	1	2	3	2	2	3	6
P_ANY_PRCPTN	0	2	5	2	2	6	8	3	3	14	8	6	7	22	27	20	18
P_ww_STRATIF	0	0	0	1	1	1	3	2	3	4	1	4	5	12	11	14	14
SHOWER	0	2	5	1	1	5	5	1	0	10	7	2	2	10	16	5	4
TSTORM	0	0	0	0	0	1	0	0	0	1	2	1	0	2	5	1	.8
REC_VCY	0	2	5	1	0	6	5	1	1	4	2	3	3	12	16	6	7
P_ww_LIQUID	0	2	5	2	2	6	8	3	3	14	8	6	7	22	27	18	17
FREZING		0	0	0	0	0	0	0	0	0	0	0	0				
SOLID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.1	1	.4
RR/6hr mm/10	0	0	0	0	0	0	0	0	0	0	0	0	0	6	8	5	5
DMO		0	0	0	0	0	0	0	0	0	0	0	0				
P_RR/6h>.1mm	0	1	3	2	2	2	4	4	3	5	11	10	4	20	26	25	19
>5 mm	0	0	0	0	0	0	1	0	1	0	1	0	0	3	5	3	3

Table 4: EM-MOS Example

7. REFERENCES

Knüpffer, K, 1997: Automation of Aviation Forecasts - Auto-TAF and Grid-Point MOS. Preprint Volume: *3rd European Conference on Applications of Meteorology*, September 23-26, Lindau, this Volume

Richter, B, 1997: Operational Use of MOS Forecasts in General Aviation (GAFOR), Preprint Volume: *3rd European Conference on Applications of Meteorology*, September 23-26, Lindau, this Volume

Mesoscale forecasts for stratospheric aircraft missions

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A forecasting system was set up to infer the impact of mountain waves for producing mesoscale temperature anomalies in stratospheric heights. It was successfully applied during a recent aircraft campaign which operated out of Rovaniemi in northern Finland between 18 Dec. 1996 and 13 Jan. 1997. The forecast information led to the successful detection of mountain induced polar stratospheric clouds on 9 Jan. 1997. For this event mesoscale forecasts, hindcast runs including grid nesting and comparisons with lidar observations and radiosonde measurements are presented.

For investigations concerning polar stratospheric clouds (PSC) the question is of prime importance *whether*, to *what extent* and for *how long* the air temperature falls below the threshold value for PSC formation. The application of a research-type NWP model (MM5) to the situation above Scandinavia can give answers for episodes, especially during measuring cmpaigns.

Demands from the steering groups of the combined German and European aircraft campaigns POLECAT (Polar stratospheric clouds, lee waves, chemistry, aerosols and transport) and APE (Airborne Polar Experiment) regarding detailed mission guidance resulted in the *ad-hoc* installation of a forecasting system. This consisted of MM5 mesoscale forecasts driven by the routine global forecast (GM) data of Deutscher Wetterdienst (DWD).

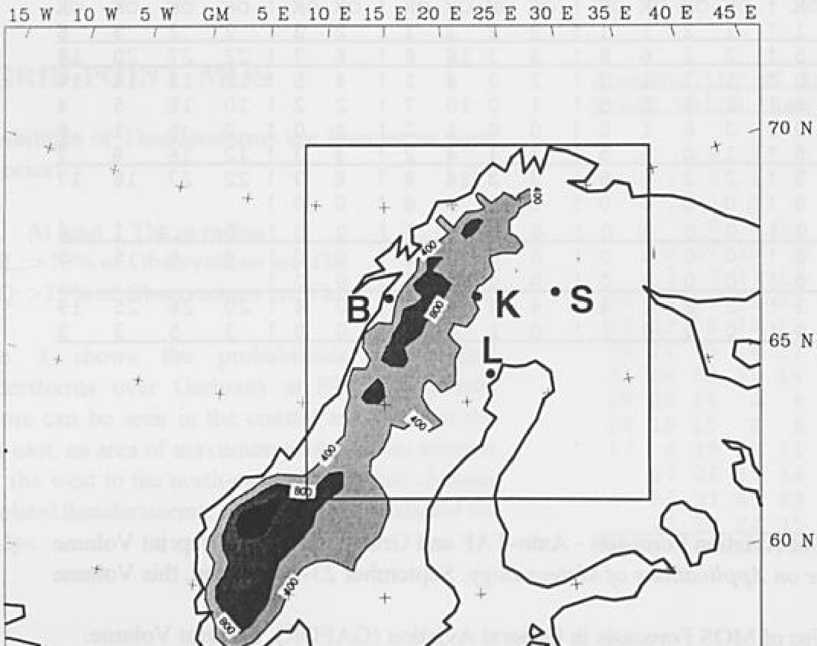

Figure 1: Computational domain of the mesoscale model covering entire Scandinavia and the Norwegian Sea. The model orography is given in increments of 400 m. Locations: Bodø (B), Kiruna (K), Luleå (L), Sodankylä (S). The box designates the nested region used in the hindcasts.

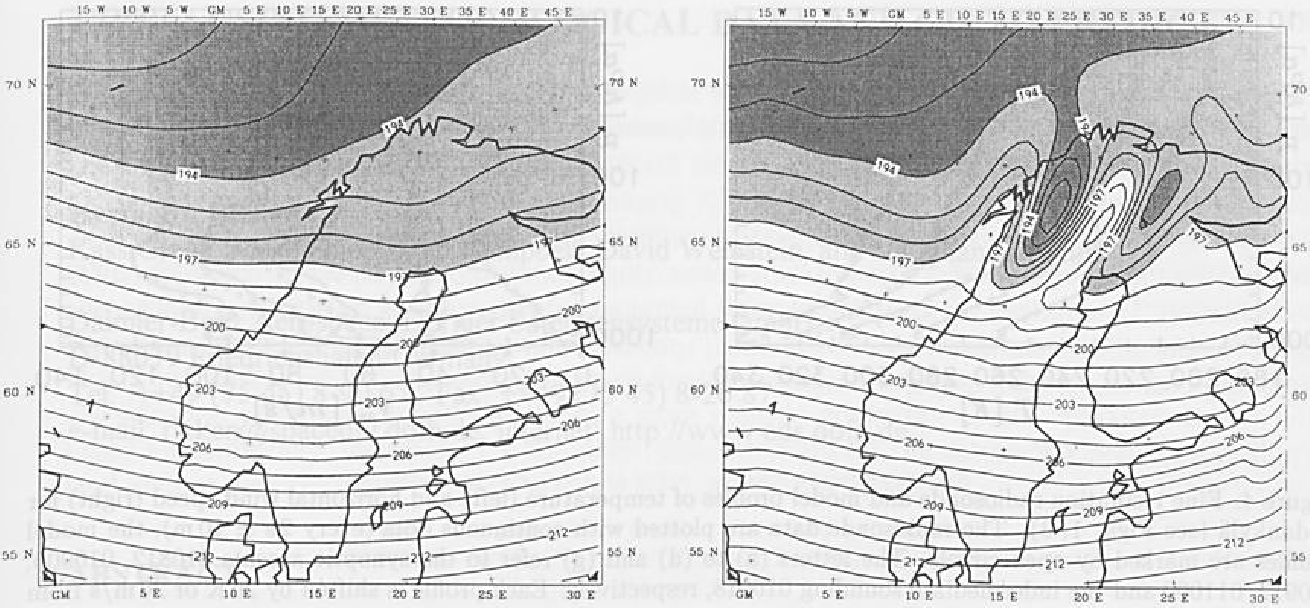

Figure 2: Forecasts of temperature on the 560 K potential temperature surface (in about 23 km) for 18 UT (+30 h) on 9 January 1997; GM (left) and MM5 results (right); values in K.

The forecast domain covers entire Scandinavia (61 × 61 meshes of 36 km each; 2200 km domain length, Fig. 1). The vertical resolution is about 0.5 km with a total of 52 levels up to 10 hPa.

The 30 h stratospheric forecast for 9 January 1997, 18 UT (Fig. 2) reveals a distinct mesoscale temperature contrast of $\Delta T \approx 9$ K over a distance of 200 km in the area above and downstream of the northern Scandinavian mountains. This is in line with vertical deformations of the potential temperature surfaces due to upward propagating mountain waves and not captured in the too coarse global forecasts (at T106 truncation; equivalent grid length of about 125 km).

An aircraft mission was launched on the basis of the mesoscale forecasts and PSC were encountered

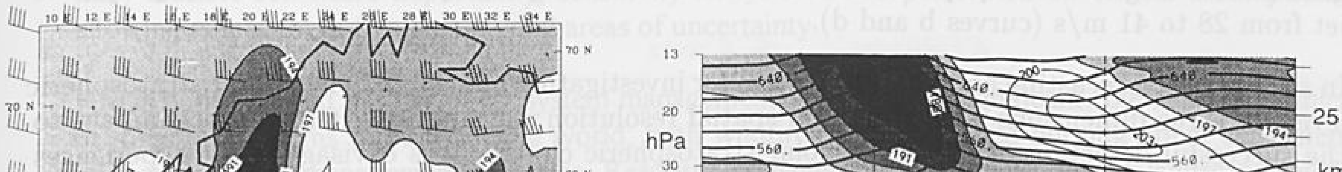

Figure 3: Hindcasts of temperature on the 560 K potential temperature surface in the nested domain at 18 UT (+ 30 h; left) on 9 January 1997; values in K (left). Cross-section of temperature (thin lines and shading; increment: 3 K) and potential temperature (bold lines; increment: 20 K) along the NW-SE oriented flight path (right). The thick line segment (left) and the dashed box (right) in the centres of the frames indicate the region of lidar observations. S: Sodankylä sounding station (cf. Fig. 4).

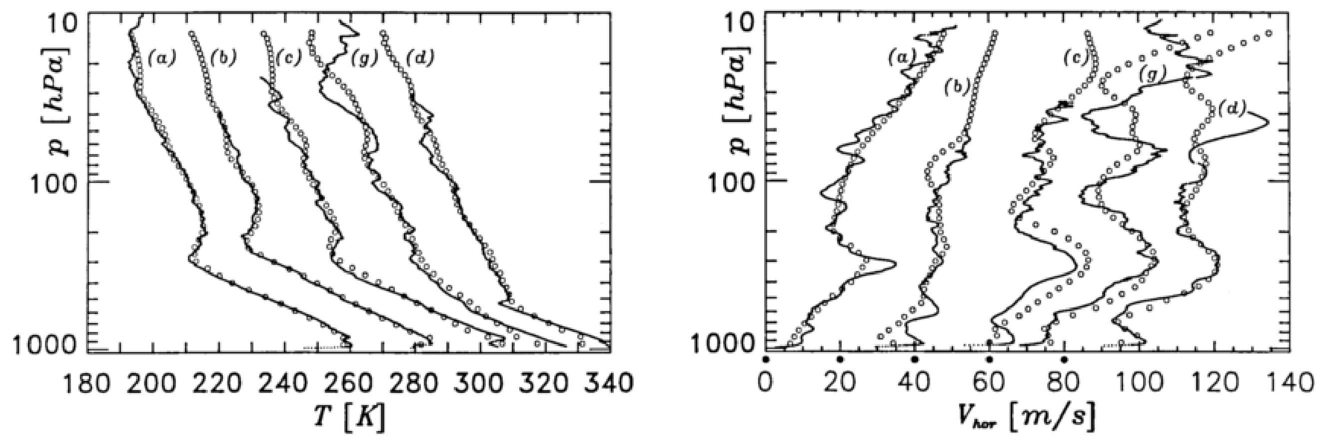

Figure 4: Fine resolution radiosonde and model profiles of temperature (left) and horizontal wind speed (right) for Sodankylä (see Figs. 1, 3). The radiosonde data are plotted with continuous dots (every $2\,s \simeq 10\,m$), the model profiles are marked by open circels. The letters (a) to (d) and (g) refer to the synoptic ascents 010812, 010900, 010912, 011000 and the indermediate sounding 010918, respectively. Each profile is shifted by 20 K or 20 m/s from the preceding one.

in both "cold spots" by an upward looking lidar system onboard the Falcon research aircraft of DLR. A comparison with a nested hindcast simulation (12 km gridsize) shows that the observed PSC was aligned with the wind and had its western edge in the region of coldest temperatures (T < 188 K; Fig. 3).

Vertical profiles from the nested simulation are compared with the only accessible high resolution (raw) stratospheric sounding data from that area (courtesy of the Finnish Meteorological Institute; Fig. 4). At the initialization time (8 Jan., 12 UT; curves a) the model temperature and wind profiles represent a remarkable accordance with the observations, very much as though they were obtained as a running mean through the many measured smaller variations. During the hindcast period the gravity wave activity is noticed in the observations and in the model resulting in systematic phase shifts between both kinds of data especially at stratospheric levels. Still, the gradual lowering of the tropopause is well covered as is the speed-up over 24 h of the tropospheric jet from 28 to 41 m/s (curves b and d).

In summary, a forecasting and analysis system for investigating mesoscale dynamics at stratospheric levels in three dimensions and with good spatial resolution was applied. It had direct impact to the successful detection of mesoscale polar stratospheric clouds. It is envisaged that experiences gained from detailed hindcasts for all events of the campaign (which are underway) will help to improve the mountain wave forecasting capabilities for future missions.

The competent assistance of A. Kaestner and R. März (DWD, Offenbach) during the set-up and daily execution of the global model data transfers is gratefully acknowledged.

A more detailed account on the forecasting system and its successful application, including a satellite image and the lidar observation, is given by

Dörnbrack, A., M. Leutbecher, H. Volkert and M. Wirth, 1997:
Mesoscale forecasts of stratospheric mountain waves.
Institut für Physik der Atmosphäre, DLR-Oberpfaffenhofen, Report No. 77, 20 pp.,
accepted for publication by *Meteorological Applications*, Cambridge University Press.

FIRE! – USING METEOROLOGICAL DATA AND GIS TO PREDICT WILD-FIRE BEHAVIOUR

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ABSTRACT

INTRODUCTION

FIRE! is a tool-based GIS application (geographic information system) application for forest fire prediction. It integrates input data on spatial fuel properties, topographic information and **temporal weather data** to form a computer-animated interactive scenario for fire prediction. A graphical user interface allows the simulation of forest fire behaviour across both time and space by specifying and editing all the essential parameters, e.g. **fuel moistures**, terrain slope, etc. The simulation package displays all relevant information like rate of spread, fireline intensity, time of arrival, etc. in raster or vector format. The complete output data is presented as GIS tool coverages and grids.

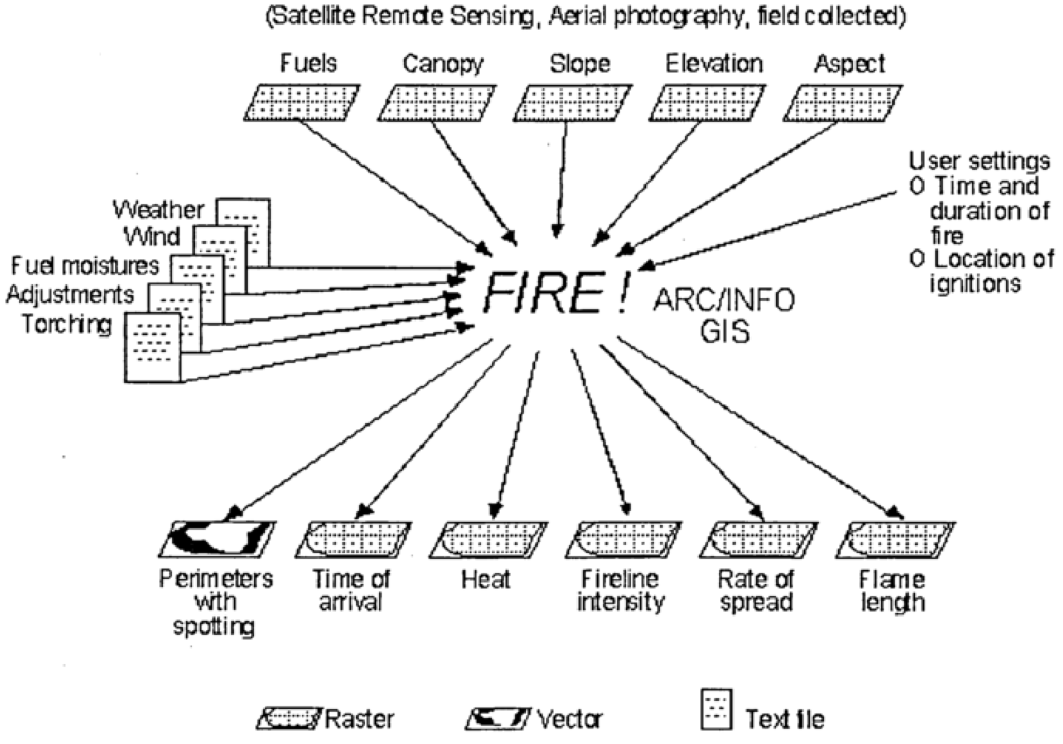
GIS, when supported by actual remote sensing data, is a powerful management and analysis tool because it allows ecosystem managers to simulate multiple future conditions across space. By linking possible future conditions to values, ecosystem managers can use GIS to narrow options to a spatially feasible set. More importantly, sensitivity analysis can be performed on critical assumptions, allowing managers to focus on pivotal areas of uncertainty.

Fire is both part and partner in ecosystem management. Fire plays a significant role in the dynamics of forest ecosystems throughout the world; both wildfires and prescribed burning affect ecosystem relationships and management activities. Resource managers must consider fire at landscape levels where GIS becomes an important management tool.

This abstract explores the use of GIS to spatially represent fire behaviour under varying assumptions of fuel type, **weather condition**, and topography. Simulating fire behaviour and effects across landscapes facilitates the prediction of future vegetation and habitat conditions. Landscape conditions that result from different management policies or assumptions can be compared, helping ecosystem managers. integrate fire into management decisions. The GIS and fire growth model can serve as a basis for further integration of ignition risks, land use values, and suppression costs that could ultimately improve decisions concerning prescribed natural fire, fire prevention, and suppression responses.

THE MODEL

FIRE! is an ArcTools-based GIS application that integrates spatial fuels and topographic data with **temporal weather**, **wind settings**, and **initial fuel moistures** to predict forest fire behaviour across both time and space. *FIRE!* allows a user to model fire behaviour by defining a fire „Scenario". The figure below presents a flow diagram for *FIRE!*. A graphical user interface (GUI) allows the user to easily specify and edit the data and parameters necessary to execute each simulation scenario. The user specifies the appropriate fire fuels, canopy cover, slope, elevation, and aspect layers required for the simulation. In addition, nonspatial data sets, including **weather**, **wind**, **initial fuel moistures**, and fuel model adjustment factors, can be created, specified, and edited. Finally, scenario parameters of ignition location, ignition shape, run time, and resolution are designated.



FIRE! simulation flow diagram

As the simulation progresses, vector representations of fire perimeters are graphically displayed. At the conclusion of the simulated burn, *FIRE!* also displays raster representations of time of arrival, heat, fireline intensity, rate of spread, and flame length for the burned area. Plots of the simulation results may be generated using built-in plotting templates or customised by the user with the plotting tools available in ARC/INFO. All of the output data is preserved as ARC/INFO coverages and grids. The user may further analyse these with the full range of capabilities of the ARC/INFO GIS environment.

INPUTS

As indicated, several types of inputs are needed to run the model, including GIS layers of fuel type, tree cover, slope, aspect, and elevation; **tabular data on weather, wind**, and **initial fuel moistures**; and user specifications of scenario parameters.

The fire fuels and tree-crown cover classifications developed using digital satellite imagery render raster data layers the depict the continuous variation of fire fuels and tree-crown cover present across the landscape. In contrast, photointerpreted delineations of fuels, tree-crown cover, et cetera can portray a deceptively homogeneous pattern of fuel and crown-cover variation across the landscape, resulting in an unrealistic prediction of fire behaviour. The spatial detail provided by the pixel classification of satellite imagery provides a more realistic prediction of fire behaviour by the GIS-based model because the imagery's 30-meter resolution portrays the complexity and composition of land-cover characteristics.

Tree-crown closure. Tree-crown closure influences wind speed reduction to midflame height and incoming solar radiation, which in turn affect fire behaviour.

Topographic layers. Variation in slope, elevation, and aspect can significantly affect fire behaviour. *FIRE!* accepts raster coverages of the topographic layers in a variety of units (e.g. degrees or percent for slope).

Weather and wind data. Weather and wind data can be obtained from a variety of sources and are input as ASCII files. Weather data are expressed for each day and include precipitation, hour of minimum temperature, hour of maximum temperature, minimum and maximum temperatures, minimum and maximum humidity, and elevation. Winds are assumed to be constant in space but to vary in time. Wind data are specified for each hour as 20-foot open windspeed, azimuth direction, and cloud cover percentages.

Scenario parameters. User-specified scenario parameters include the burn simulation start and end dates and times, and the spatial and temporal resolution of calculations performed during the simulation.

Finally, a data set identifying the location and configuration of a fire ignition must be specified. Fire ignitions may be established as points, lines, and/or polygons and are entered interactively by clicking on the screen at the desired ignition locations. The user may also adjust the predicated rate of spread to match actual observed rate of spread by fuel type.

OUTPUTS

After defining the burn scenario, the model simulation can be executed. As the model performs the necessary fire behaviour calculations, vectors are displayed indicating the fire's perimeter at a user-specified time interval.. At the completion of the simulation, raster data layers are produced providing the flamelength, fireline intensity, time of arrival, hear per unit area, and rate of spread of the fire for every pixel within the burned perimeter.

MODELLING HIGH-RESOLUTION PRECIPITATION

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ABSTRACT

High-resolution precipition models are of interest for assessing the risk of storms and floods, and in the design of structures. While there is a large literature about models for daily precipitation and on their successful and widespread application, models for higher-resolution precipitation, such as hourly precipitation, are fewer and less developed.

This work reports on an analysis of process of hourly precipitation amounts at Stuttgart, Germany, for the period 01/01/1964 - 31/12/1990. We investigate the various aspects of the process including its serial correlation structure and the point process describing the onset of each precipitation event. Properties of the process of amounts that exceed a given threshold are discussed, as is the effect of varying the threshold.

We compare the fit of Markov chains to the process of daily events with that of hidden Markov models. Unfortunately, when considering time periods shorter than one day, such models would seem to require a large number of parameters. Secondly daily rainfall models are often on the assumption that the rainfall depths (on wet days) are independently distributed. This assumption is unrealistic for shorter-duration rainfall and thus; for example the sequence of hourly rainfall depths (during a rain spell) is not approximately serially independent.

We therefore also consider the performance of other types of models for the Stuttgart data. In particular we consider a Neyman-Scott Cluster process and also an alternating renewal process for the occurrence of rainfall combined with a separate conditional model for the depths in wet periods, where the consecutive depths are not assumed to be serially independently distributed.

A study of Low Level Jet and Ekman Spiral profiles over Belgium

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ABSTRACT

It is not unfrequent that the boundary layer wind observed in the routine high resolution (around 50 m) radiosoundings over Belgium exhibits a Low Level Jet or an Ekman type profile.
One station (Uccle, at 100 m above sea level) proceeds to observations at 0000Z and 1200Z and is located a hundred km from the coast in that part of Belgium which is still rather flat.
An attempt is made to identify the suitable conditions for the appearance of these peculiar structures and of their time of disappearance due to distabilisation by time dependant processes like solar heating or interaction with larger scale features.
Some consequences are deduced on the diurnal modulation of the surface wind and on the vertical momentum exchange.
It is suggested that, due to the interest ot these features by themselves and of the validation of their realistic simulation by high resolution models, initiative should be taken in order to implement through WMO bodies an (at least) European exchange of high resolution boundary layer data already available by standard equipment.

IMPACT OF DYNAMICS ON DIURNAL TEMPERATURE EVOLUTION FOR CLEAR SKY SITUATIONS OVER BELGIUM

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ABSTRACT

The aim of this study is to quantify the impact of dynamics on the surface air temperature at screen height (1.5 m) over Belgium. The three-dimensional mesoscale model MAR (Modèle Atmosphérique Régional developed at the Université Catholique de Louvain) is used to examine the role of the above-mentioned processes in clear sky and weak horizontal advection situations. The MAR is nested in ECMWF re-analysis data in order to isolate the role of the mesoscale flow and to evaluate the importance of the three-dimensional representation for the chosen situations. If the large-scale forcing is small, the development of the mesoscale circulations has a significant impact on the temperature distribution over Belgium.

1 Introduction

The topography and the surface characteristics are important forcing for situations characterized by clear sky and weak horizontal advection. Mc Queen et al. (1995) have shown that the topographical forcing and vertical decoupling have a significant impact in a relatively wide and shallow valley, even if the synoptic forcing is quite strong. Whiteman and Doran (1993) distinguish four mechanisms that can produce distinct relationships between winds over and within a valley. These processes are thermal forcing, downward momentum transport, forced channelling, and pressure driven channelling. Although, strictly speaking, all these considerations can not be applied to the Belgian Ardennes (highlands situated at the South and South-East of Belgium with moderately complex topography), some concepts and mechanisms remain valid and useful to understand local circulations. Since the flow produced over the Belgian Ardennes results from the superposition of a mesoscale flow dependent on local conditions and a large-scale flow, this study plans to give a qualitative estimate for the change induced on the surface air temperature at screen height (1.5 m) by the local circulations.

2 Description of Experiments

The model used for these clear sky simulations over Belgium is the three-dimensional mesoscale model MAR (Modèle Atmosphérique Régional) described in Gallée and Schayes (1994). The simulation domain, represented with 50 by 50 horizontal grid points and is centered on Louvain-la-Neuve (50.7 N ; 4.5 E), is nested in ECMWF (European Center for Medium-Range Weather Forecasts) analysis. The horizontal resolution is fixed to 10 km. The time step is 40 seconds. The vertical discretisation contains 30 levels, with an increased resolution close to the surface. The first model level is at 10 m height. The topography is set to a constant value at the lateral boundaries to avoid the generation of spurious circulations generated in that area. The atmospheric and surface variables are initialized and forced with ECMWF data. The simulation results are compared with observations from climatological data network. In 1990, the Belgian climatological network contained about 125 reliable thermometric stations scattered over the country.

The development of mesoscale circulations depends on the strength of the large-scale forcing. In order to examine the impact of the large-scale over Belgium, two situations are considered : 16 March 1990 and 9 April 1990, characterized respectively by a weak and a dominant forcing with weak horizontal gradients. For each atmospheric situation, two experiments will be considered : the first is a run performed with the standard version of MAR ; for the second run, the dynamics is switched off, which means that there are no horizontal exchanges between grid cells : the MAR is in this case a collection of one-dimensional (column) models.

3 Impact of Dynamics : Weak Large-Scale Forcing

First, the situation of 16 March 1990 is examined. The run was started 15 March 1990 at 6 am UT. This period was characterized by (South or South-West) warm tropical airflow from a high pressure system centered over Eastern Europe. The 15 and 16 March are cloud free and exhibit weak wind situations. Observations show that the large-scale wind at 10 m height is particularly weak with speeds between 1 and 3 m/s over Belgium. Such a situation favours the role of local valley circulations. Bogren and Gustavsson (1991) have observed that the variation in air temperature is totally smoothed out in situations in which there is an ambient wind speed exceeding 3 m/s. Between 2 and 3 m/s, they underlined that the degree of wind exposure in valleys is of importance for the magnitude of the air temperature differences.

The difference between simulated results and observations for minimum and maximum surface air temperature is presented in Figure 1. The root mean square (noted rms) errors for minimum and maximum temperatures are respectively 1.24 K and 1.86 K. The night temperature distribution over Belgium is generally well represented, particularly over the North and the center of the country, and also over the highlands. The highest error is found in the South of Belgium. The daytime temperature shows a systematic error of about 2 K over the whole domain. Examining the RMIB (Royal Meteorological Institute of Belgium) sounding at station Uccle for the 16 March 1990 at 10 am UT, this deficiency is explained by a temperature inversion at 700 m height not represented in the ECMWF data.

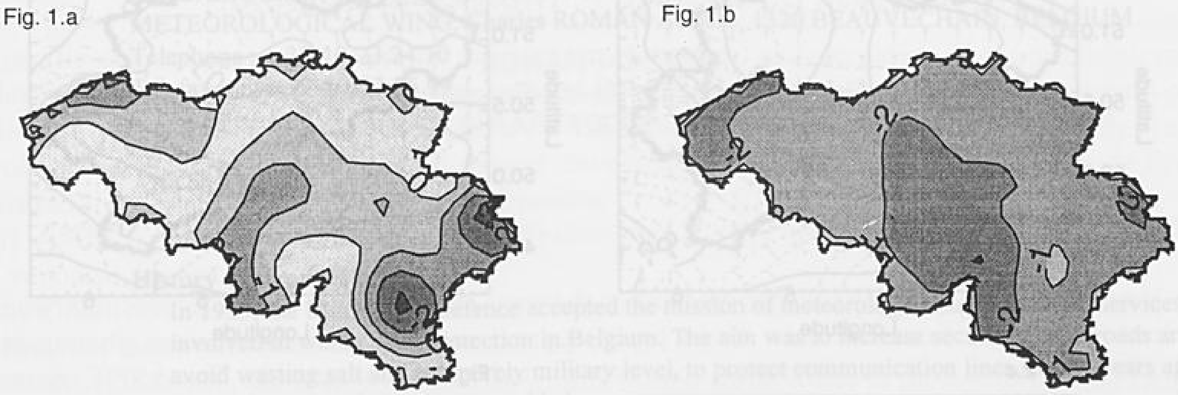

Figure 1 : The contour lines (the contour interval is 1K) represent the differences between the simulated (a) minimum or (b) maximum surface air temperatures and the observations taken from the climatological network for the situation of 16 March 1990.

If the dynamics is switched off, the rms errors reaches 5.64 (minimum temp.) and 3.44 K (maximum temp.). This error increase underlines the importance of the processes generating mesoscale circulations. Figures 2.a and 2.b represents the temperature difference (16 March 1990 at 4 am and 2 pm) between the experiments with and without dynamics, and the surface wind field with dynamics. A first evaluation of results shows a surface air temperature colder during the night and slightly warmer during the day for the simulation including dynamics. This difference is, not surprisingly, more important in the regions with steep topography. Let us now explain the role of the dynamics especially active in the Belgian Ardennes.

A mesoscale flow pattern is present over the Ardennes area and is superimposed on the large-scale flow. The katabatic wind is sufficiently strong to locally modify the large-scale flow : typical values of katabatic wind speed are about 4 to 6 m/s at 10 m height (decreasing to about 2 m/s at 400 m height), which is greater than the large-scale wind speed. The transport of cold air from highlands to lowlands of Belgium explains the presence of fresh air around the Ardennes hill. The coastal area is less affected by the cooling because of the distance with the Belgian Ardennes. Referring to the four mechanisms quoted by Whiteman and Doran (1993), the thermal forcing leading to down-valley winds is then a relevant process during the night. This is also commonly observed under the two following conditions corresponding to our simulation, i.e. large diurnal cycle (clear sky situation) and weak upper-level winds.

This is not the case during daytime. The anabatic wind is less intense than the katabatic wind, with speeds ranging from 0.5 to 2 m/s. Such values seem too weak to counteract the large-scale wind speed and direction. The efficiency of the warming resulting from anabatic wind and proportional to the surface elevation is weak. The dominant mechanism is the downward transport of momentum which is favoured by (i) the surface warming generating unstable or neutrally stratified conditions and (ii) gravity waves produced over the Ardennes area. In consequence, this situation gives rise to wind directions in the surface layer similar to the geostrophic wind directions aloft.

4 Impact of Dynamics : Dominant Large-Scale Forcing

Another atmospheric situation, the one of 9 April 1990, is considered. During this period, a high pressure zone was situated over the Atlantic ocean. It was responsible for (North-East) continental cold air currents over Belgium, which gave low temperatures and frost during the night. The main difference with the 16 March 1990 case lies in the strength of the large-scale forcing : the wind speed varies between 3 and 6 m/s.

This time, the thermal forcing process has a limited role : the large-scale wind is sufficiently strong to counteract katabatic and anabatic winds, and to reduce the pressure gradients generated by the temperature differences between topography bottom and top. Therefore, the downward momentum transport of geostrophic wind is the dominant mechanism influencing the wind speed and direction. It is caused by turbulent mixing (especially active during the daytime) and gravity waves. Although it is less important, the forced channelling mechanism may contribute also to align the wind direction along the side of the "Ardennes hill". Both these processes contribute to produce a wind direction close to the geostrophic wind orientation, even for the first level which seems not influenced by the topographical characteristics. It is found that (i) the surface and geostrophic wind directions are similar and (ii) the forcing wind (North-East) is quite well aligned with the Ardennes area (Figures 2.c and 2.d).

The advection has a limited effect, since horizontal gradients of temperature and moisture are weak. As shown in Figures 2.c and 2.d, the temperature differences between the runs with and without dynamics are therefore not really significant. In conclusion, the use of a one-dimensional model over Belgium is justified if there exists a large-scale forcing sufficiently strong to avoid the development of local circulations and if the horizontal gradients are weak (favoured by an anticyclonic situation).

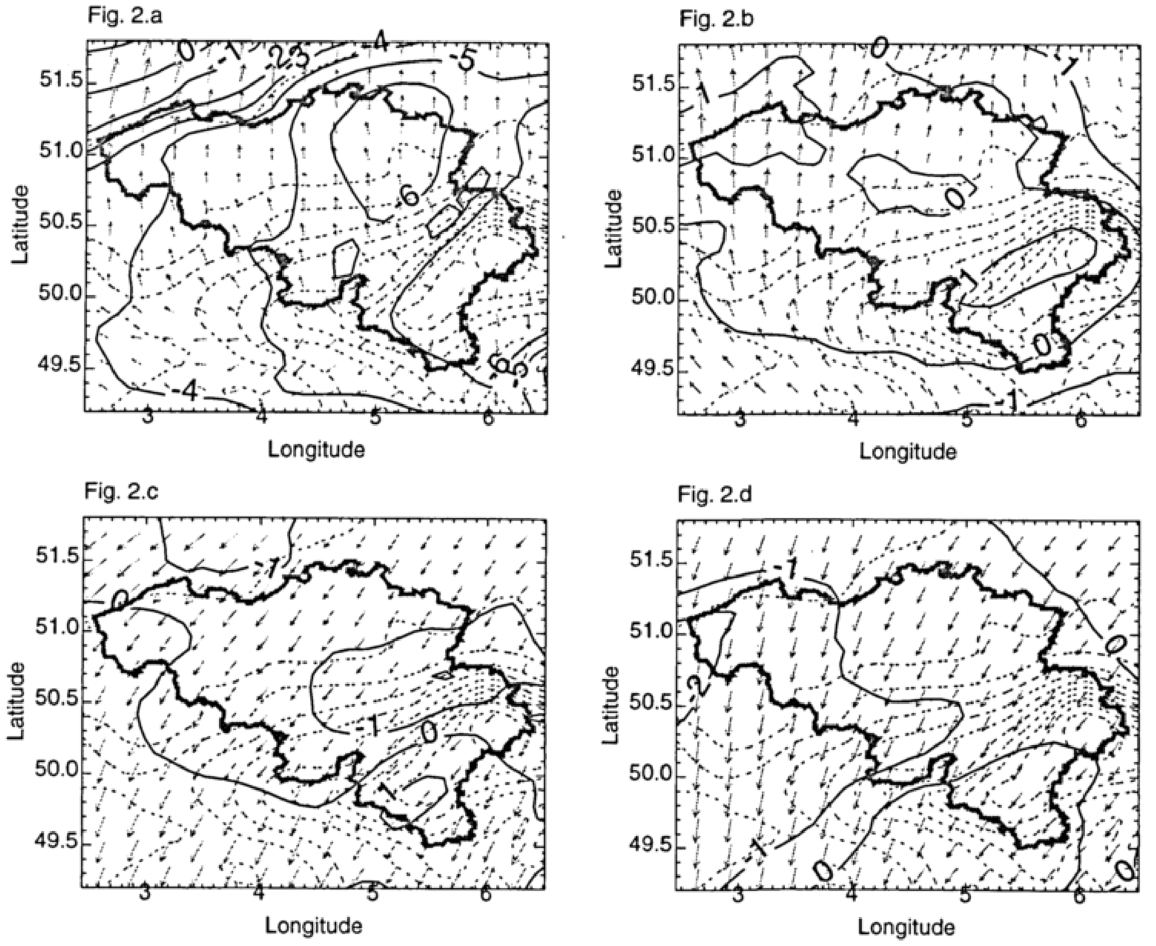

Figure 2 : The Figures represent the surface air temperature difference (solid contour lines) for the 16 March 1990 at 4 am (a) or 2 pm UT (b), and for the 9 April 1990 at 4 am (c) or 2 pm UT (d), between the MAR with- and without dynamics. The dotted contour lines represent the surface elevation. The contour interval is 1 K for the temperature and 50 m for the topography. The surface wind field is also plotted.

5 Conclusions

The role of the three-dimensional dynamics over Belgium is examined. Situations characterized by limited advection effects and a clear sky are considered. Such conditions allow a maximum development of mesoscale circulations : mainly katabatic winds during night-time, anabatic winds and a sea breeze during daytime. With a weak large-scale forcing, their role is particularly important with respect to the minimum surface air temperature : katabatic winds produce a cooling ranging from 3 (coastal region) to 6 K (Belgian Ardennes) as compared to simulations with the dynamics switched off. The maximum temperature is less affected, with a difference of 1 K in order of magnitude. This is mainly due to less intense circulations and vertical turbulent mixing. If the large-scale forcing contains wind speeds larger than about 3 m/s, the mesoscale circulations are inhibited and the large-scale wind dominates the local flow. The one-dimensional approach is justified if the following conditions are satisfied : sufficient wind speed from the large-scale forcing and weak horizontal gradients.

References

Bogren, J., and Gustavsson, T.: 1991, 'Nocturnal Air and Road Surface Temperature Variations in Complex Terrain', *Int. J. Climate* **11**, 443-455.

Gallée, H., and Schayes, G.: 1994, 'Development of a Three-Dimensional Meso-γ Primitive Equations Model, Katabatic Winds Simulation in the area of Terra Nova Bay, Antarctica', *Mon. Wea. Rev.* **122**, 671-685.

Mc Queen, J.T., Draxler, R.R., and Rolph, G.D.: 1995, 'Influence of the Grid Size Resolution on Wind Field Predictions from an Operational Mesoscale Model', *J. Appl. Meteor.* **34**, 2166-2181.

Whiteman, C.D., and Doran, J.C. : 1993, 'The Relationship between Overlying Synoptic-Scale Flows and Winds within a Valley', *J. Appl. Meteor.* **32**, 1669-1682.

METEOROLOGICAL ROAD PROTECTIONING DURING WINTER IN BELGIUM DECISION-AID SYSTEM

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ABSTRACT

History - Introduction

In 1953, the Ministry of Defence accepted the mission of meteorological support to the services involved in winter road protection in Belgium. The aim was to increase security on the roads and to avoid wasting salt and at a purely military level, to protect communication lines. A few years ago, the environmental element was added.

Starting from practically nothing, the progress made in technology (satellites, radar, numerical models) has permitted more precision in the forecasts. In spite of this, information received, especially that concerning the actual road surface, remained meagre.

The services involved in road protection were made aware of the problem by the Meteorological Wing of the Air Force. The Walloon region reacted in a very constructive manner.

Concept & Development

The system is an ice prediction and warning system, designed specifically for the highway engineer to help with the problem of icy roads.

The system is in **three** phases:

(1) **Thermal mapping**

It is obvious that we can't have road sensors at every point of potential interest in the road network. Previous studies showed that each road has its' own thermal profile.

In other words, certain sections of the road are always colder than others, whilst some are always warmer. The road network was therefore scanned, with the help of infra-red cameras mounted on vehicles, in various weather conditions.

(2) Implantation of **Meteo stations**

Based on the information received from the thermal mapping and the experience of the highway engineers, 15 "forecasting" stations (completely equipped) and 34 "operational" stations (limited equipment) were set up along the main roads and motor ways in the Walloon region.

The road temperature measured at a station, combined with information received from the thermal mapping of the road section, permits us to know the temperature over the whole stretch of road.

(3) A **mathematical model** made, to combine the thermal mapping, the values initially measured by the stations and the forecasts made by a professional meteorological institution - this last charged with providing a forecast on what the air will be doing.

This model gives information on what will happen at road surface level, such as cooling curves and a forecast map of the complete road network, valid for the expected minimum temperature, with a colour code clearly showing the roads to protect.

Conclusion

The benefits of the system are:

- The reduction of winter maintenance costs.
- Safe roads.
- Rational, scientific aid for management decisions.
- Management decisions can be confidently made in advance.
- The environmental damage is reduced to a strict minimum.

THE NOWCASTING OF THUNDERSTORM AND PRECIPITATION WITH ASPIC

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I. INTRODUCTION

The Nowcasting is a general concept devoted to the very short range weather forecasting, when the lead time varies from one hour to six hours approximately. It includes various phenomena such as : convection and thunderstorms, fog, strong winds, and cyclogenesis. The ASPIC system is a very short range forecasting system devoted to the forecast of thunderstorms (up to 30 mn range) and precipitation (up to 2h range) over the district Ile-de-France (surrounding Paris). The ASPIC project (ASPIC = Approche Synthétique de la Prévision Immédiate à DIRIC, i.e. Comprehensive Approach for Nowcasting at DIRIC) has been designed, in order to gather on the same display facility the different sources of information relevant for nowcasting with many functionnalities (zoom, image loop, superimposition, time-extrapolation ...). These informations, displayed on the ASPIC workstation at high resolution and high frequency, come mainly from SAFIR lightning system (detecting "intra-cloud as well as the cloud-to-ground lightning"), from Radar images and from satellite pictures, in addition to conventional observations and NWP model outputs. We refer Richard (1990) for details on the SAFIR system (see also this volume) and Pircher et Chèze (La Météorologie, 1993) for a review on atmospheric electricity. The ASPIC system has been presented in details (data-base and functionnalities) in previous ECAM conferences (Juvanon du Vachat et al., 1993 and 1995).

That paper is mainly devoted to the presentation of recent developments and applications of the ASPIC system in two directions : (i) hydrological applications that use the forecast advection scheme for radar images ; (ii) forecasting the thunderstorms, as dangerous phenomena for aviation traffic. More precisely in the hydrological context the ASPIC system appears as a very good tool. On the other hand, the forecast of thunderstorms appears difficult, but the context has recently changed with some studies of the thunderstorms by the Nowcasting research team (Sénési, CNRM/Toulouse), and also in the frame of the 4MIDaBLE european aeronautical project.

II. ASPIC IN THE HYDROLOGICAL FIELD

Since ASPIC is a multi-functional approach and is a friendly software system, it is very easy to take the core programming system to devote for specific applications. In the hydrological context the radar imagery plays a central role in order to identify and to forecast precipitation zones and occurrence. In the ASPIC system, we use radar local images every 5mn, at the pixel resolution of 1km and with the reflectivity distributed in 16 levels. A particular attention has been devoted to the time-extrapolation technique of this imagery, developed and evaluated by the CNRM/PI team in a large statistical sample of meteorological situations (see Juvanon du Vachat et al., 1995) and also in different particular situations (Bocrie, 1994). Such a scheme use two successive images within a 10 mn time-interval to deduce an advection field, which can be used to compute a forecasted Radar image.

We now mention the different hydrological applications, which use the ASPIC system and the specific outputs computed from the radar images (observed or forecasted).These applications are developed in the district Ile-de-France (around Paris), but some applications also exist with other districts , like the EDF application for the river «Ardèche « (in the South-East of France), in close collaboration with the HYDRAM project developed at Météo-France. For the Ile-de-France district there are the three following applications :
(i) AMELIE, with the sewage plant for rainwater, at Orly airport, in collaboration with the Lyonnaise des Eaux company.
(ii) OMEDIS, with the sewage works at Bonneuil (near Roissy airport), in collaboration with Direction Départementale de l'Equipement du Val d'Oise.
(iii) IMAGES, with the sewage managing station for the waste water in the whole Ile-de-France district, in collaboration with the Syndicat Interdépartemental d'Assainissement de l'Agglomération Parisienne.
These applications need mainly precipitation forecast at 1h-2h range, for extreme situations in cases (ii) and (iii), but even for moderate rainfall in case (i) (20 mm event). an example of the output of the ASPIC station in case (i) is given in the Figure below.

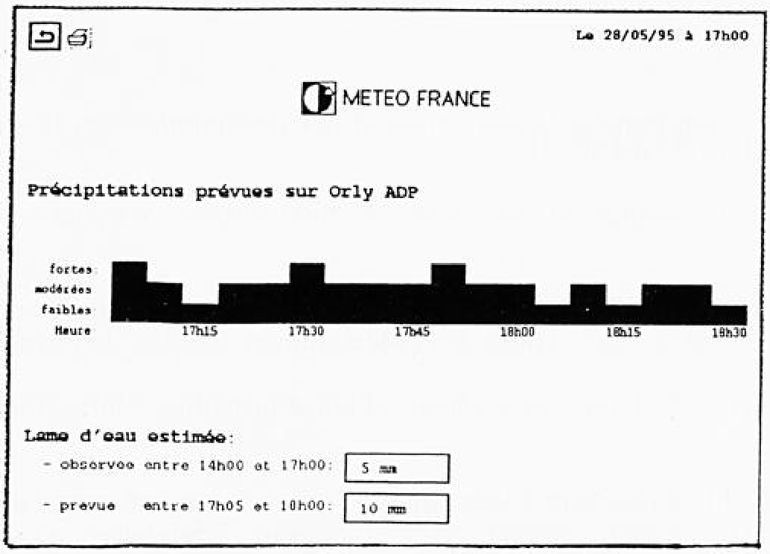

Figure : + Precipitation forecast from 17h up to 18h 30 (on 28 may 1995).
+ Total rainfall (observed and predicted) over the Orly catchment area.

III. ASPIC IN THE AERONAUTICAL FIELD

The first aim of the ASPIC project was to forecast the thunderstorms as well as the precipitations. But for various reasons much work has been done concerning the precipitation forecast rather than concerning the thunderstorms forecast, that remains a very difficult challenge. We refer the communication by Dhonneur (1993) for an example of the meteorological situation (25 may 1992) difficult to forecast several hours ahead. The first page of this paper intitled "Bras de fer" has been written to explain the forecast error to the managers of the Roland-Garros tennis exhibition ! Such a meteorological situation is also a good example to illustrate the role of urban heat island to regenerate the convection (Lossec, private communication).

Concerning the Air Traffic Control, there is a need for very short range forecast of thunderstorm, as demonstrated in the european aeronautical 4MIDaBLE project. But is is difficult to characterize thunderstorm, on the contrary of rain, which is visible on Radar images. Obviously the Safir information, especially the display of electrical density can represent an area of important lightning activity, which can be interpreted as an area of danger for aviation traffic. In the frame of this project a number of discussions take place to identify the meteorological hazards, dangerous for the aviation traffic , by merging the Radar and Safir (electrical density) imageries.

In a general meaning, the nowcasting concept can also include the knowledge of conceptual models of convective situations, like those developed by Browning (1986). A very useful material is given by Roux (1993), which presents the different conceptual models on thunderstorms, as deduced from the intensive experiments done in the great plains of the U.S.A. A real challenge is to try to apply these concepts to meteorological situations in Europe, where the relevant parameters can be different. In particular, in the district Ile-de-France we can mention again the role of heat urban island. The key parameters generally considered are the following : CAPE (Convective Available Potential Energy), Kinetic Energy of the Horizontal Wind Shear and also CIN (Convection Inhibition). Different convective indexes have been also built to diagnose the possibility of thunderstorms from routine meteorological parameters, like the traditional lifted index (Galway, 1956). As a conclusion we refer Sénési and Thepenier (1997) for a study of the predictability of thunderstorms in the district Ile-de-France from such convective indexes. In their extensive study about fifty parameters are considered, and the more relevant for our district are defined and will be implemented in the near future in the ASPIC system.

References

Bocrie E., 1995 : Prévision immédiate des orages et des précipitations en Ile-de-France: projet ASPIC. Note de travail de l'ENM N°510.

Browning, K.A., 1986 : Conceptual models of precipitation systems. Weather and Forecasting, 1, 23-41.

Dhonneur G., 1993 : La Prévision Immédiate, une obligatoire Synergie "hommes-machines". Conférence Européenne sur les applications de la Météorologie (Oxford, Septembre 1993).

Galway, J. G., 1956 : The lifted index as predictor of latent instability. Bull. Amer. Met. Soc., 37, 528-529.

Juvanon du Vachat R., J.L. Chèze and S. Sénési, 1993 : Nowcasting of storms and precipitations over Ile-de-France. The ASPIC project. First European Conference on Applications of Meteorology (Oxford, 27th Sept.-1st Oct. 1993) 4p.

Juvanon du Vachat R.,P. Thomas, E. Bocrie, G. Monceau, Ph. Cosentino, S. Sénési, D. Tzanos, and J.L. Boichard, 1995 : The precipitation Nowcast scheme in the ASPIC project. Second European Conference on Applications of Meteorology (Toulouse, Sept. 1995) pp. 29-32.

Richard P., 1990 : SAFIR system. An application of real-time VHF localization to thunderstorm monitoring. 9th Conference on Atmospheric Electricity, Kananaskis, Canada J21-J26.

Roux F., 1992 : Les orages. Météorologie des grains, de la grêle et des éclairs. Editions Payot.

Sénési S., R. M. Thepenier, 1997 : Indices d'instabilité et orages: Applicabilité en Ile-de-France. Soumis à "La Météorologie", 44 pages. see also this Volume .

METEOROLOGICAL EXPERTISE DURING AN INTERNATIONAL EXERCISE ON ENVIRONMENTAL EMERGENCY RESPONSE.

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ABSTRACT

International exercises on environmental emergency response are carried out in co-operation between the RSMCs (*) Bracknell and Toulouse in their own area of responsibility. From rough output of pollutant transport diffusion models and their expertise, forecasters of both sides elaborate and cast a joint statement which mainly synthesizes model results with critics and reserves about the real total depositions and layer concentrations of the pollutant in the atmosphere.

At Météo - France two kinds of tools are used :
the atmospheric global variable mesh (ARPEGE) and the transport diffusion model (MEDIA) :
the forecaster contribution in some meteorological conditions is essential.

During the bilateral exercise simulating an incident on the site of Cernavoda (Romania) on the 12/07/96, different behaviours appeared between the Météo - France's models in Toulouse and UKMO's one in Bracknell. We pointed out the different contributions of forecasters dealing with concentration and deposition scheme critics about pollutant. Several points have been pointed out :
1) The treatment of the spatial release at the initial time;
2) The small scale structure of the wind fields close to the orography;
3) The scavenging process by the precipitation's.

1) Initial release.

This human analysis allows to validate and criticize the outputs from the models at the time of the first pollutant release in the atmosphere. A detailed analysis by the forecaster, of the observed initial meteorological situation when the first pollutant is released, allows to criticize and validate the automatic outputs given by the various models available in the RSMCs.

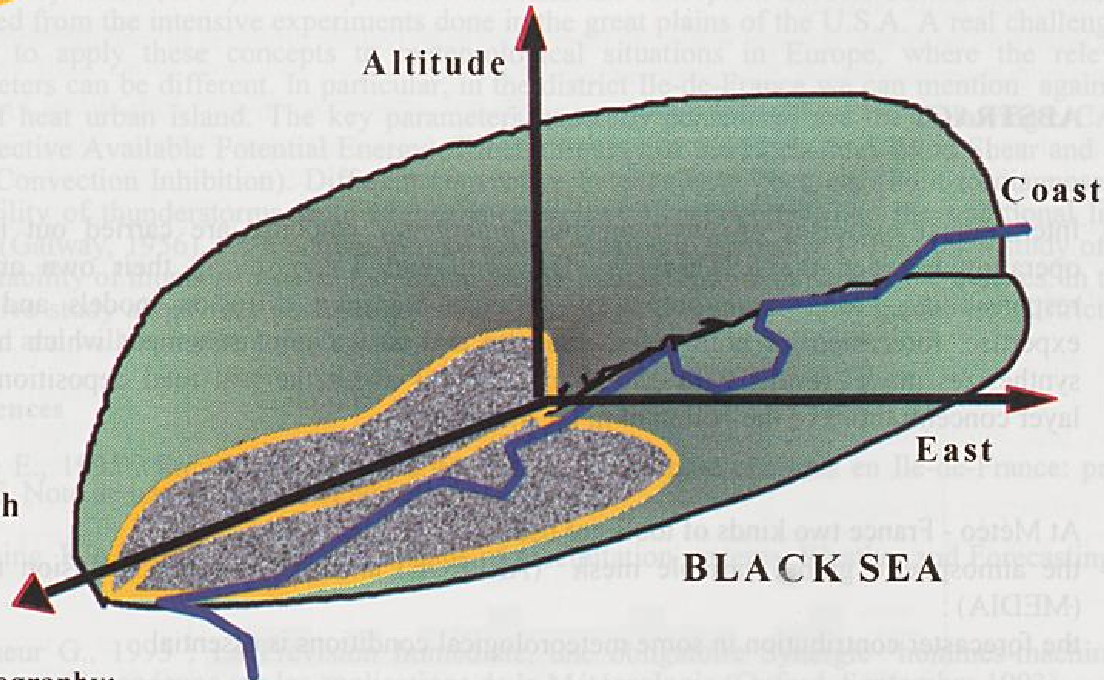
* RSMCs. (Regional Specialised Meteorological Center)

contribution examples : during Cernavoda exercise with convective situation

3D distribution of the pollutant 6 hours after the initial release:

Evaluated by the forecaster by taking into account mixing and transport;

Simulated by ARPEGE model without pertinent small scale mixing.



2) Orography:

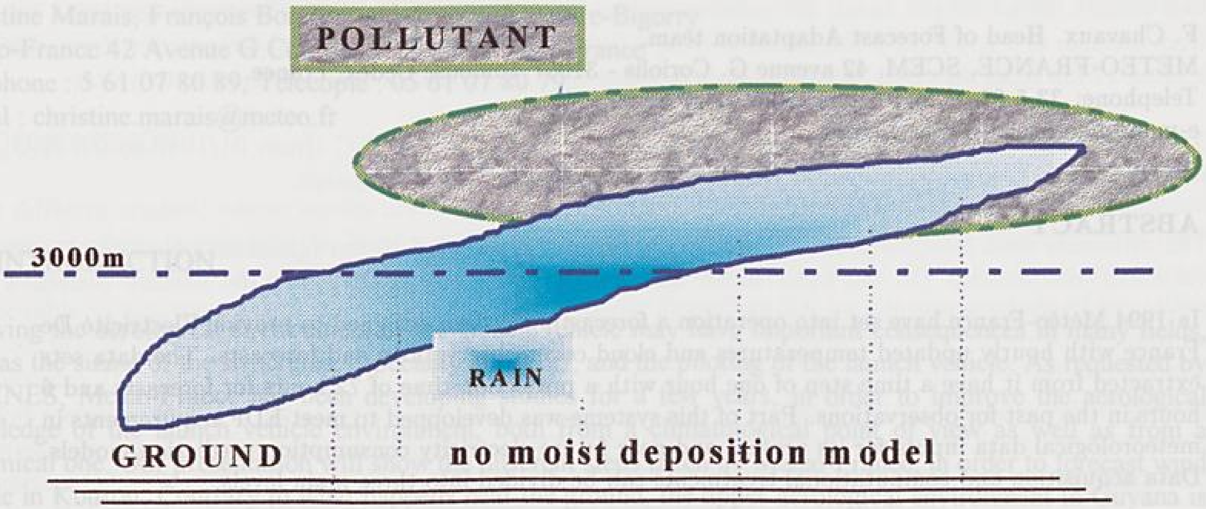
Sometimes, small structures (subgrid scale) are not always taken into account and can have a strong influence on the pollutant diffusion as well in direction as out concentration. The mesh of the French global model over Romania is about 35 km. During the exercise, the RSMC Braknell ran a global model having a mesh of about 100 km . Under these conditions some divergence appears between the two models, especially over the orography. With an underestimation of orography, the pollutant diffusion of the UKMO's model was more important than ARPEGE's one, in the synoptic fluxes. The ARPEGE model with a more realistic orography suggests more complex pattern due to the rising of the particles over the mountains, the bypassing and the diurnal evolution.

3) Scavenging process by the precipitation.

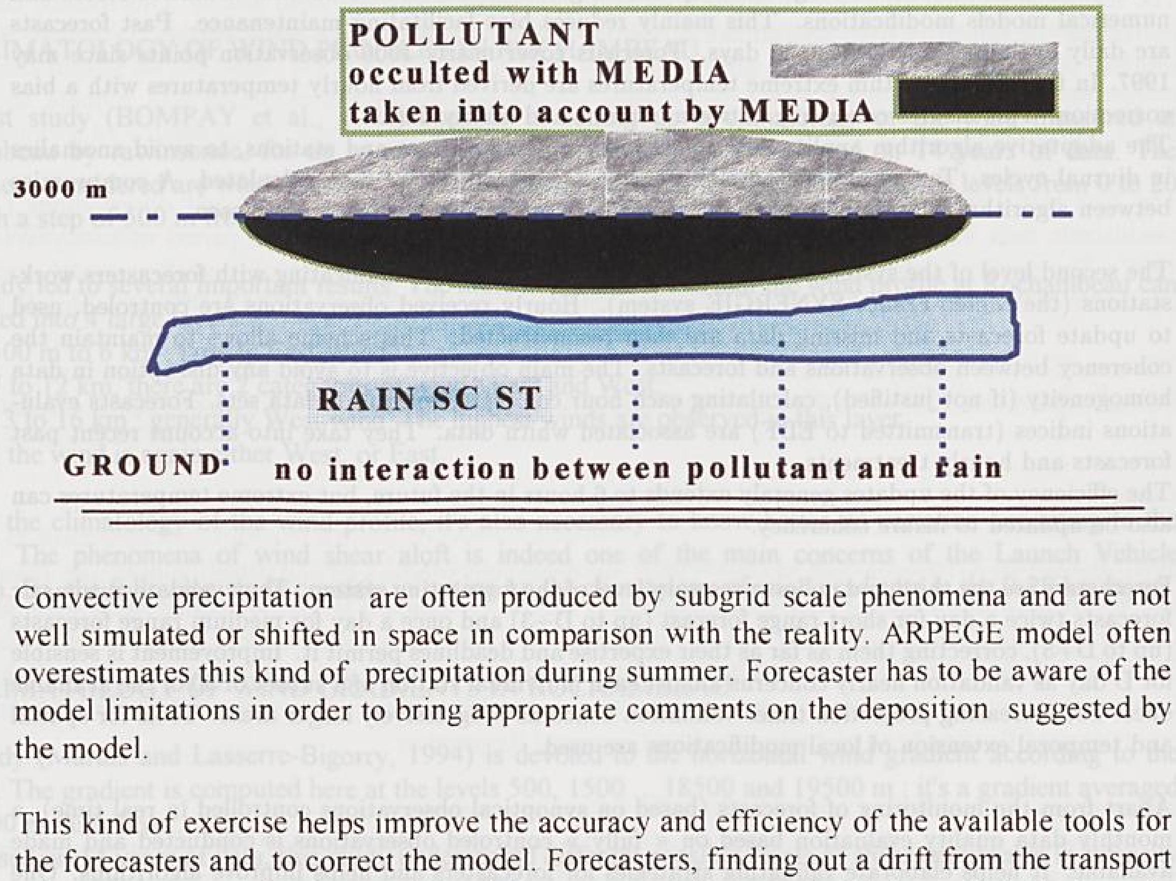
When precipitation occurs within an air column, only a fraction of the pollutant between 0 and 3000 m is taken into account for deposition. According to this principle location of the pollutant and precipitation, we can induce some unrealistic results because of wet deposition not simulated by the model or unrealistic deposition by rain.

Example :

a) wet deposition is not simulated with ARPEGE on the 12/07/96



b) Case where ARPEGE makes a unrealistic deposition



Convective precipitation are often produced by subgrid scale phenomena and are not well simulated or shifted in space in comparison with the reality. ARPEGE model often overestimates this kind of precipitation during summer. Forecaster has to be aware of the model limitations in order to bring appropriate comments on the deposition suggested by the model.

This kind of exercise helps improve the accuracy and efficiency of the available tools for the forecasters and to correct the model. Forecasters, finding out a drift from the transport scheme suggested by the model, might use a real-time tool which could help them in giving a more realistic solution.

TEMPERATURE AND CLOUD COVER FORECAST FOR ELECTRICITY CONSUMPTION PREDICTION.

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ABSTRACT

In 1994 Météo-France have set into operation a forecasting system designed to provide Electricité De France with hourly updated temperatures and cloud cover observations and forecasts. The data sets extracted from it have a time step of one hour with a projection time of 72 hours for forecasts and 6 hours in the past for observations. Part of this systeme was developped to meet EDF requirements in meteorological data inputs for its present and near future electricity consumption prediction models. Data acquisition and computational treatments can be divided into three main levels.

The initially predicted values result from the objective interpretation of the ARPEGE french numerical weather forecast model (twice a day), completed and secured by the European Center model (once per day). Estimation of forecasts by Statistical Model Ouput linear regression for temperature and total cloud cover are corrected through an adaptative algorithm to take into account evolutive errors and numerical models modifications. This mainly reduces bias facilitating maintenance. Past forecasts are daily evaluated on the last 30 days. Forecasts cover nearly 1000 observation points since may 1997. In the 1997 algorithm extreme temperatures are derived from hourly temperatures with a bias correction. This insures coherency between extreme and hourly data.
The adaptative algorithm applies only to selected projection times and stations, to avoid anomalies in diurnal cycles. Temporal and spatial extension of corrections are then calculated. A compromise between algorithm adaptative «reactivity » and rate of convergence has been chosen.

The second level of the system is implemented on data servers communicating with forecasters workstations (the Météo-France SYNERGIE system). Hourly received observations are controled, used to update forecasts and missing data are then reconstructed. This scheme allows to maintain the coherency between observations and forecasts. The main objective is to avoid any disruption in data homogeneity (if not justified), calculating each hour complete, controled, data sets. Forecasts evaluations indices (transmitted to EDF) are associated whith data. They take into account recent past forecasts and hourly treatments.
The efficiency of the updates generaly extends to 6 hours in the future, but extreme temperatures can also be updated to insure coherency.

Forecasters are the third and no less necessary level of the forecasting system. They validate automatic forecasts twice a day for short range forecast (up to D+3) and once a day for medium range forecasts (up to D+5), correcting them as far as their expertise and deadlines permit it. Improvement is sensible for D day as validation nearly concerns almost each individual station of a subset of 50 of the available ones. For increasing projection times validation concerns progressively larger areas. Tools for spatial and temporal extension of local modifications are used.

Apart from the monitoring of forecasts (based on synoptical observations controlled in real time), a monthly data quality evaluation based on « fully » controled observations is conducted and made available. It helps elaborate validating strategies for forecasters and helps improve algorithms. One of the main teaching of this powerfull tool has been to set into evidence the accuracy of forecasters corrections from the short range up to the medium range were it was not previously believed to be so sensible.

MODELLING THE AEROLOGICAL ENVIRONMENT IN GUYANA

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1. INTRODUCTION

Knowing the aerological environment of the launch vehicle may have important consequences in many fields, such as the sizing of the structures, especially at lift off, and the piloting of the launch vehicle. As requested by the CNES, Meteo-France has been developing studies for a few years, in order to improve the aerological knowledge of the launch vehicle environment, both from a climatological point of view as well as from a dynamical one. Our presentation will show the different steps taken by Meteo-France, in order to forecast wind profile in Kourou. Contrary to what happens near the ground, the upper aerological environment in Guyana is not wellknown and is only based on the empirical knowledge of forecasters working at the Weather Services in Kourou and Rochambeau. So several studies have been developed to acquire a better knowledge of wind fluctuations and to forecast wind profile in Kourou.

2. CLIMATOLOGY OF WIND PROFILES IN ROCHAMBEAU

The first study (BOMPAY et al., 1994) consists in setting up a climatology of the wind measured at Rochambeau by rawinsonde, for up to now there has not been any. It is based on 14 years of data. The parameters considered are wind direction, speed, zonal and meridian winds, on 23 standard levels from 0 to 20 km, with a step of 500 m from the ground to 2000 m, and with a step of 1000 m above.

This study led to several important results. The must important one is that the wind profile at Rochambeau can be divided into 4 large layers :
- from 500 m to 6 km : largely East Wind.
- from 7 to 12 km, there are 2 categories of wind : East and West.
- from 13 to 16 km : generally West wind. The highest winds are observed in this layer.
- above, the wind is again either West, or East.

Besides the climatology of the wind profile, it's also necessary to know better its variation according to the vertical. The phenomena of wind shear aloft is indeed one of the main concerns of the Launch Vehicle Division. So, the following study consists in setting up the climatology of wind gradients in the 0-20 km layer.

3. CLIMATOLOGY OF WIND GRADIENTS IN ROCHAMBEAU

The study (Marais and Lasserre-Bigorry, 1994) is devoted to the horizontal wind gradient according to the vertical. The gradient is computed here at the levels 500, 1500 ... 18500 and 19500 m ; it's a gradient averaged in a 1000 m thick layer.
Also based on 14 years of data, this study underscored different possible levels of shear occurrence in intensity (500 m above 12500 m) as well as in direction (500 m, between 6500 and 17500 m).

These two studies concern the site of Rochambeau. In order to know if these results can be used for the site of Kourou, forecasting being the final goal, it's now necessary to determine if the winds for the two sites have similar distributions.

4. COMPARISON OF WIND MEASUREMENTS IN KOUROU AND ROCHAMBEAU

The meteorological centers of Kourou and Rochambeau have a rather different geographical location. These two centers, about 60 km apart, are situated on the Guyana coast. However, Kourou is located 3 km away from the sea, in a completely flat savanna area, whereas Rochambeau is situated downstream from some hills around 17 km from the coast. So differences in lower layers fluxes can occur between the two sites.

The study (Marais et al., 1996) is based on a 42 days sample at 12 UTC (from 01/1993 to 07/1995), with wind measurements at Kourou made by the CNES during a specified campaign.

The differents tests concluded to the "equality" of winds from 1 to 20 km (gaussian populations with same variances and means). On the other hand, the "equality" can't be accepted in the surface boundery layer (ground to 500 m), where the local relief has an impact on the flux.

Finally, we can accept the conclusions of the two previous studies for the site of Kourou (except near the ground). Moreover, in order to forecast the wind in Kourou, it will be possible to use the results of the statistical adaptation method developed for Rochambeau at 12 UTC, as described in the following section.

5. WIND FORECAST BY STATISTICAL ADAPTATION IN ROCHAMBEAU

The statistical method used here is in fact a local adaptation of a forecast wind profile. This method consists in correcting the forecasts from operational prediction models by using wind observations. The study is divided into two steps.

5.1 *Climatological study*

The first step (Bompay and Marais, 1996) was to compile a climatology of wind observations (12 UTC rawinsonde data in Rochambeau) and of 24 hour range wind forecasts over a period of two years (1991 - 1992). The quality of direct model outputs was also determined. The numerical prediction model used here is the model of the "European Centre for Medium-Range Weather Forecasts" (ECMWF or more simply CEP).

The conclusion is that direct wind forecasts are of medium quality, according to the different levels.
Besides, speed forecasts more than direction forecasts are likely to be improved by a statistical adaptation.

5.2 *Statistical adaptation*

In the second step (Bompay and Marais, 1996), we computed wind speed and direction forecasts from 0 to 20 km, by using Multiple Linear Regression Equations for the 23 standard levels. We tested MOS method (Model Output Statistics) and PP method (Perfect Prediction). We considered as predictors meteorological fields both in grid points and through their Principal Component Analysis. We also tested to regroup the predictors by Canonical Regression. Finally, the best method here is the PP method, using meteorological fields at 12 grid points around Rochambeau and regrouped by Canonical Regression.

The analysis of the different results leads to the following conclusions :

* on the jacknife file, the statistical method leads to better wind forecast than the numerical prediction model, for all levels, whether we consider or not speed or direction categories.

* on the test file, there are just a few levels for which the statistical method leads to worse results than the numerical model :

Generally speaking, the quality of the statistical forecast is rather good, even if it is different from one level to the other.

6. CONCLUSION

These different studies, whose results are briefly described here, have improved the knowledge of aerological environment of the launch vehicle. Now a rather complete climatology of wind and wind gradient upon 1000 m, in the 0-20 km layer, is available for Rochambeau. Besides, the results at 12 UTC for Rochambeau are transposable to Kourou, except in the surface boundary layer from 0 to 500 m. Finally, because of the rather good quality of the statistical adaptation, it's possible to use this method in order to forecast wind in Rochambeau, from the ground to 20 km, at 24 hour range. Since the populations of Rochambeau and Kourou are of the same kind and as the nearest grid point to Kourou and to Rochambeau is the same, this statistical method can also be used for Kourou at 12 UTC, from 1 to 20 km. In future, if required, it will be possible to make this prediction method operational, thanks to collaboration between the Central Weather Service in Toulouse and the Weather Service of the European Space Center.

7. ACKNOWLEDGMENTS

We wish to thank Frédéric Chavaux for his valuable teaching of different statistical methods and for his suggestions during all the steps. We acknowledge helpful and stimulating discussions with Isabelle Donet and Danièle de Staerke. Our thanks to Brigitte Billaut for her patience in typing the manuscripts. These studies were supported by French Space Agency (CNES).

8. REFERENCES

Bompay, F., A. Lasserre-Bigorry, C. Marais, 1994 : "Etude descriptive des profils de vent à Rochambeau", *Note du SCEM n° 15.*

Marais, C., A. Lasserre-Bigorry, December 1994 : "Etude sur les gradients de vent à Rochambeau", *Rapport d'étude n° OSETGV00048.*

Marais, C., F. Guillemot, B. Nechad, S. Trouillot, February 1996 : "Comparaison des mesures de vent à Kourou et Rochambeau", *Rapport d'étude n° OSECVK00108.*

Bompay, F., C. Marais, March 1996 : "Prévision de vent à Rochambeau - Etude climatologique", *Rapport d'étude n° OSCPVR00109.*

Bompay, F., C. Marais, March 1996 : "Prévision de vent à Rochambeau - Adaptation statistique", *Rapport d'étude n° OSPVRA00110.*

BIOCLIMATOLOGICAL POTENTIAL OF ALBANIA

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ABSTRACT

The work productivity in agriculture is determined by the natural conditions. In this paper a comparative evaluation of productivity is presented, that may be applied to different areas of Albania.

The estimation is conducted according to the quantity of bioclimatical pote which is calculated based on the formula:

$$P.B.C. = Kp * \Sigma t > °C/1000.$$

For Albanian conditions, the biological productivity is determined in general from the heat resource and from the water security.

For different options of the coefficient of biological productivity, which values change and are determined in general, according to a logaritmic law, the estimations of maximal P.B.C., are made for the Albanian territory, referring to the data of 172 meteorological stations.

The results are charted and presented in a map to the scale of 1:500 000.

The biological productivity is estimated according to the quantity of P.B.C. and for the most part of Albania has the values 2.2 (high) and 3.4, that is considered as very high.

Also, in the paper the necessary comparisons are made as to the conditions and resources that nature offers in different areas of the country, as well as comparisons with the values of maximal P.B.C. of other European countries.

ANALYSIS OF CLIMATE ANOMALIES IN THE AREA OF CROATIA IN 1996

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ABSTRACT

Climate conditions in Croatia are analysed each month relative to the longer period averages. Depending on public request it is done even more frequent, for some extraordinarily meteorological events, and results are forwarded to media.

This paper presents extraordinarily climate conditions during 1996 on the territory of Croatia. Special attention is paid to the analysis of the first part of June 1996 when extremely high temperatures were registered on all Croatian meteorological stations. Mean daily temperature as well as the daily maxima during the first half of June 1996 was significantly higher than the 30-years average (1961-1990) as can be seen in Fig. 1, for five selected stations. The maximum measured daily temperatures in 1996. on those stations were: Osijek, 34.0 °C (10.VI), Zagreb Maksimir, 33.3 °C (11. VI), Rijeka, 35.1 °C (11. VI), Split-Marjan, 34.8 °C (12. VI), Lastovo, 34.7 °C (12. VI) and Dubrovnik, 33.2 °C (13. VI).

At Zagreb-Grič station continuous measurements started in 1862, and the average daily temperature registered on 10, 11, and 12 June 1996 (27.1 °C, 27.2 °C and 27.0 °C, respectively) are highest observed values on these days since the beginning of measurements.

On the other side, September was marked as extremely cold and extremely rainy month relative to the average in almost whole country. Large number of cloudy days (cloudiness higher than 8/10) was registered at the most of stations. This is the maximum of cloudiness for the 30-years period (1961-1990), while at those stations with very long time series such maxima appears rarely. For instance, at Zagreb-Grič there were 17 days marked as cloudy, while more cloudiness was registered only once during the whole previous measurements period, in 1912 (19 days), as can be seen in Fig. 2.

April suprized Zagreb with the maximum snow cover since the beginning of measurements. Such event is very rare in April (Fig. 3), until now recorded only several times.

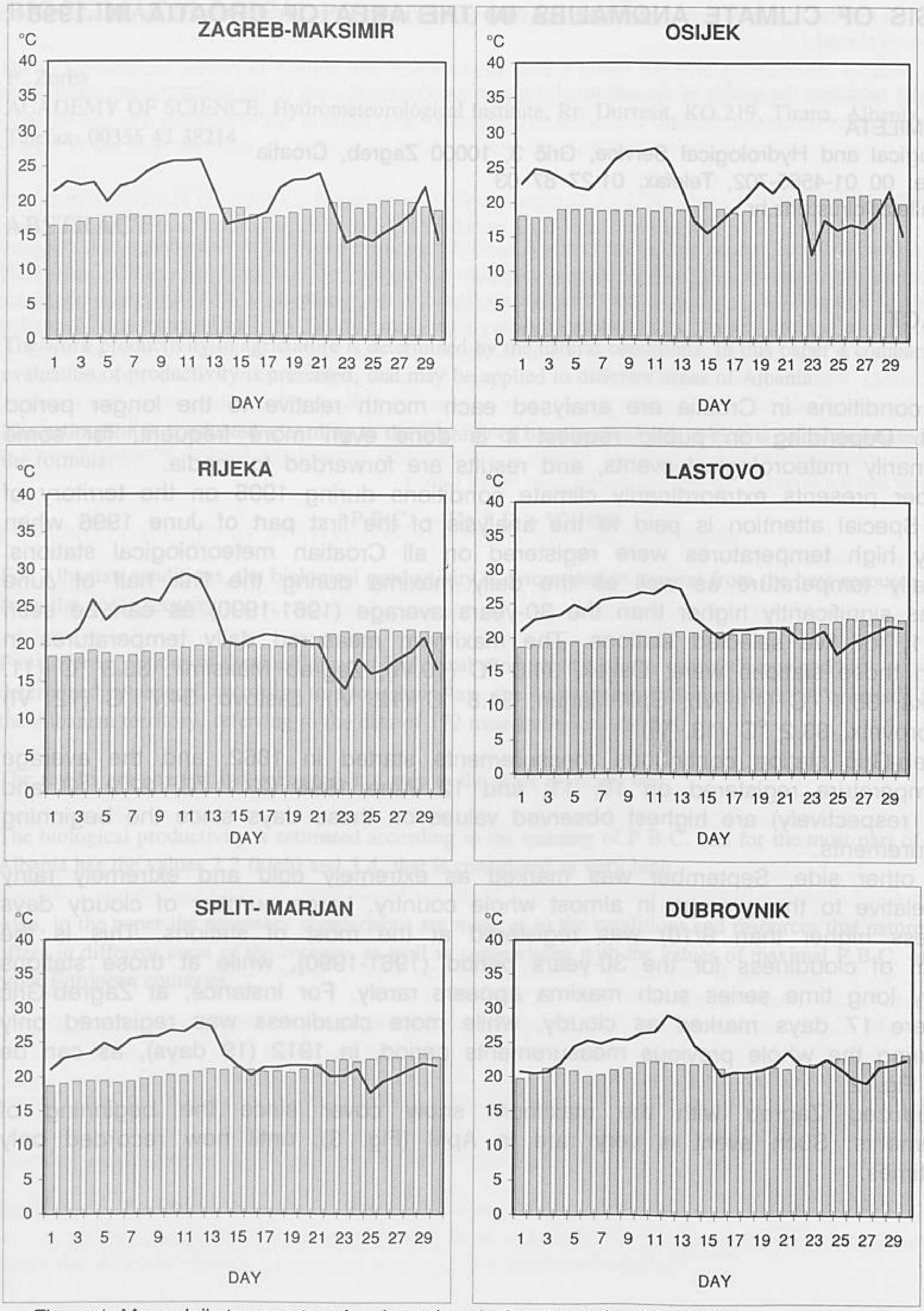

Figure 1. Mean daily temperature for six stations in Croatia during June 1996 compared to the long-term means values (1961-1990)

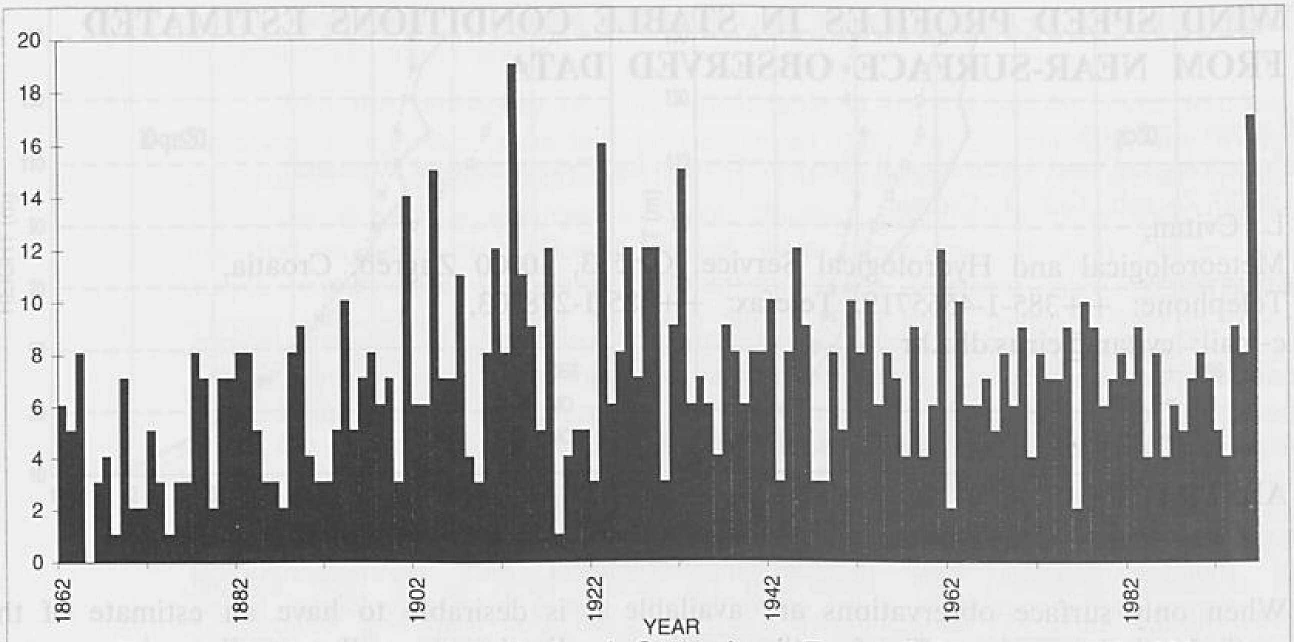

Figure 2. Monthly number of cloudy days in September at Zagreb Grič in period 1862-1996

Figure 3. Maximal height (cm) of snowfall (mm) reistrated at Zagreb-Grič during the period (1895-1996) in April

WIND SPEED PROFILES IN STABLE CONDITIONS ESTIMATED FROM NEAR-SURFACE OBSERVED DATA

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ABSTRACT

When only surface observations are available it is desirable to have an estimate of the vertical wind speed profile for the routine application in pollutant dispersion control. This paper shows the applicability of two relatively simple wind models in very stable conditions. The estimations (from temperature at 2 and 35 m and wind speed at 35 m above ground) are performed up to 150 m over the level terrain of the natural gas finding and exploitation place Molve in northern Croatia. The models-estimated wind profiles are tested against tethered balloon sonde measurements performed during two periods - 13-17 March 1983 and 16-19 October 1984.

One of the models applied is the model based upon Monin-Obukhov similarity theory (MO) with the local similarity functions. Following one of the approaches from the literature (Holtslag, 1984), local model based upon surface layer similarity theory has been applied even up to 150 m. The other applied model (Bergström, 1986) is a combination of a local surface layer wind model based upon the Monin-Obukhov similarity theory and the Ekman type model with the constant eddy-diffusivity (MOE). The two stable categories considered are defined with the use of the Kazanski-Monin stability parameter μ. The known similarity functions for stable conditions (Businger et. al., 1971) are replaced with local relations 1) $\Phi_m=1+z/L$, $\Phi_h=0.74+z/L$ ($10<\mu\leq50$) and 2) $\Phi_m=1+0.1z/L$, $\Phi_h=0.74+0.1z/L$ ($\mu>50$). With intent to attain the best agreement of the every single modelled wind profile with the corresponding observed profile, local relations are determined by changing the coefficient by the z/L in the known functions.

The agreements between two models and observations (OBS) are ilustrated in figure 1. The better skill of the combined type model described above is for less stable local conditions ($10<\mu\leq50$), while the better skill of the model based upon Monin-Obukhov theory only is for the stronger stable conditions ($\mu>50$). Up to the 100 m level the model based upon the Monin-Obukhov theory only can serve well in both stable classes.

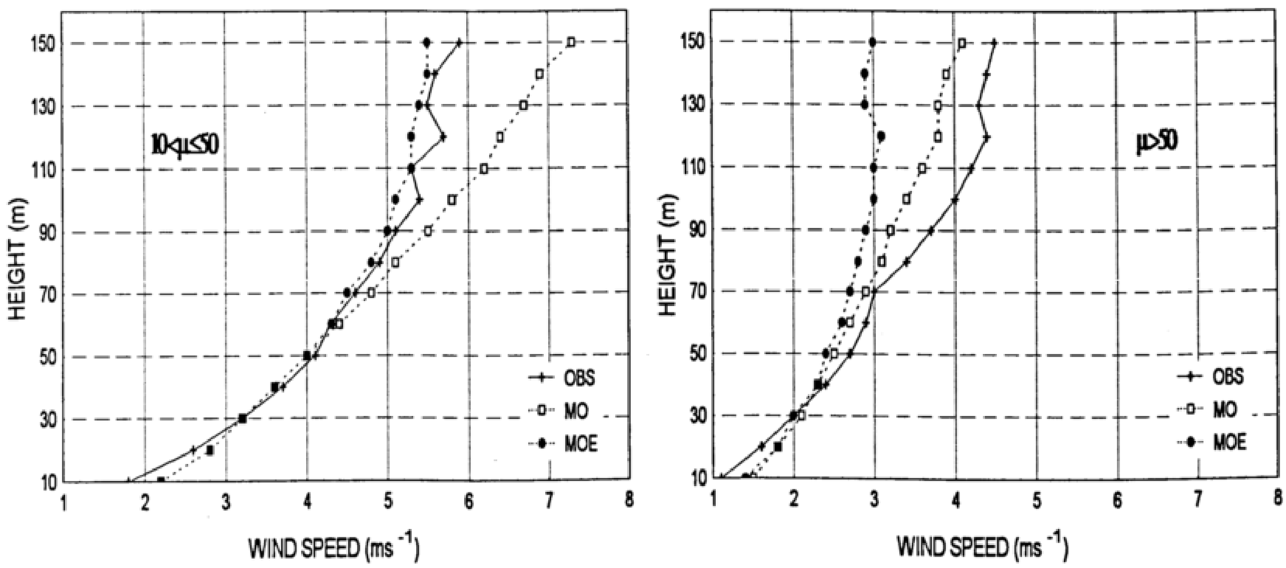

Figure 1. Mean wind speed profiles under two stability classes at Molve during the periods 13-17 March 1983 and 16-19 October 1984 - observed (OBS), model upon Monin-Obukhov similarity theory only (MO) and two-layer model (MOE) (Monin-Obukhov similarity theory model in the surface layer and Ekman type model above).

References:

Bergström, H. 1986: A simplified boundary layer wind model for practical application, J. Clim. Appl. Met., 25, 813-824.

Businger, J.A., Wyngaard, J.C., Izumi, Y. Bradley, E.F., 1971: Flux profile relationships in the atmospheric surface layer, J. Atmos. Sci., 28, 181-189

Holtslag, A.A.M., 1984: Estimates of diabatic wind speed profiles from near-surface weather observations, Boundary-Layer Meteorol. 29, 225-250

THE BIOMETEOROLOGICAL BASIS FOR TOURISM

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ABSTRACT

The comparison between biometeorological conditions in different regions has a great importance in the promotion of tourism, because it insures the possibility of choosing the best climate for choosing the holiday destination, depending on wishes, needs and health of tourists.

There are several ways to determine the biometeorological conditions. In spite of obvious advantages of biometeorological models, because in assessment of thermal comfort they include meterorological and nonmeteorological parameters, sometimes it is more convenient to use a biometeorological index, specially to compare different climates. In this paper the summer biometeorological conditions in Croatian towns are analyzed by means of TWH index, which includes the influence of temperature, wind speed and humidity on thermal sensation. The biometeorological conditions for 22 towns in different climatic regions of Croatia are determined by means of the probability of occurrence of different thermal sensations for daily mean values and for the values of biometeorological index at 2 p.m. for 30-year period (1961-1990).

The selected stations represent different climatic regions in Croatia: the eastern part of Croatia, with the continental lowland climate (three stations), the northwestern part of Croatia, where the prevailing continental lowland climate is under stronger maritime influence (five stations), the transitional mountainous area in the central part of Croatia separated from the Adriatic sea by the Mount Velebit (1600 m) (three stations), the hinterland karst area on the front side of Dinaric Alps, directly exposed to the maritime influence (two stations) and the northern (five stations) and mid part (four stations) of eastern Adriatic coast.

In the whole continental lowland of Croatia the prevailing mean daily thermal sensations during summer are comfortable and warm (about 40-50% each of them). while all other sensations are relatively rare (Fig. 1). Anyway. there are some differecnces between eastern and nortwestern part. In the eastern part (Osijek. Požega and Slavonski Brod) the probability of occurrence of comfortable and warm days is almost the same. and in the northwestern Croatia (Bjelovar. Varaždin. Zagreb and Karlovac) the differences between these sensations are greater. and in some towns comfortable days exceed the warm ones about 20%. The exception is Karlovac with the meteorological station situated in the cente of the town. The temperature is there higher and air flow weaker than at the meteorological stations in other towns. which are mainly situated in the suburb area. The differences between regions and even between towns in each region are more pronounced for the thermal sensation at 2 pm. In Osijek and Požega warm and hot afternoons prevail. while very hot and comfortable are rarer. At the same time. in Slavonski Brod. where meterological station is located in the open area. exposed specially to the west. the comfortable. warm and hot afternoons have similar probabilities of occurrence. while very hot ones are rarer than in other two towns in this region. In the northwestern Croatia warm prevail. and comfortable afternoons are more frequent than hot ones. except in Bjelovar and Karlovac. Bjelovar. in the eastern region of this area seems to have the regime more similar to that in eastern Croatia. while the

reason for different biometeorological conditions in Karlovac is the location of the station described above.

With the probability of 60% comfortable is by the far the most frequent sensation in summer according to the mean daily values. although the towns are situated at different altitudes (Fig. 1). The situation at 2 pm shows greater differences at various altitudes. In Slunj. situated 100 meters lower than Ogulin and 300 m lower than Gospić. prevail wam afternoons. while in Ogulin and Gospić comfortable afternoons will appear more frequent than warm ones. Warmer sensations (hot and very hot) are in Slunj more frequent than in other two towns. while lower ones (cool and rarely even cold) in Ogulin and Gospić will exceed those in Slunj.

On the contrary from the continental Croatian towns. in the Adriatic karst hinterland and along the Adriatic coast prevail warm summer days (Fig. 1). Only exception is Senj. a town famous by its frequent and strong bora. Due to this wind. which is not rare even in summer. the biometeorological conditions are different than in all other places on the coast. The prevailing sensation is comfortable. and even cool days are more frequent than hot ones. Comfortable days appear rarer than warm ones. but at the northern Adriatic they are about twice more frequent than hot ones. In the mid Adriatic differences are smaller directio to the south. and in Hvar and Split the probabilities of comfortable and hot days are almost the same. Although the most southern. Lastovo has the biometeorological conditions more similar to those in northern Adriatic. The meteorological station in Lastovo is situated at the top of the hill. surrounded by the sea and is exposed to the winds from all sides. more than Split and Hvar. where stations are in woods. It has to be emphasized that Rovinj. at the western coast of Istria peninsula. has the biometeorological conditions more similar to the mid Adriatic ones than to the other stations in the northern Adriatic. The sensation very hot appears very rarely in mean daily values of biometeorological index TWH. and only in mid Adriatic. At 2 pm this sensation can be expected in all towns along the Adriatic coast as well as in the karst hinterland. Moreover. it is the most frequent sensation in summer afternoons in Knin. According to this result. Knin is the hotest town in Croatia. On the Adriatic coast. very hot afternoons appear more often in greater urban areas (Rijeka and Split) than in other towns of the respective region. The only exception is again Senj where very hot aftrnoons are even more frequent than in Rijeka. probably because the station is situated in town and surounded by houses. Generally. Senj has specific thermal sensation distribution. different from all other places on Adriatic coast. because of greater frequency of extreme thermal sensations than in other towns.

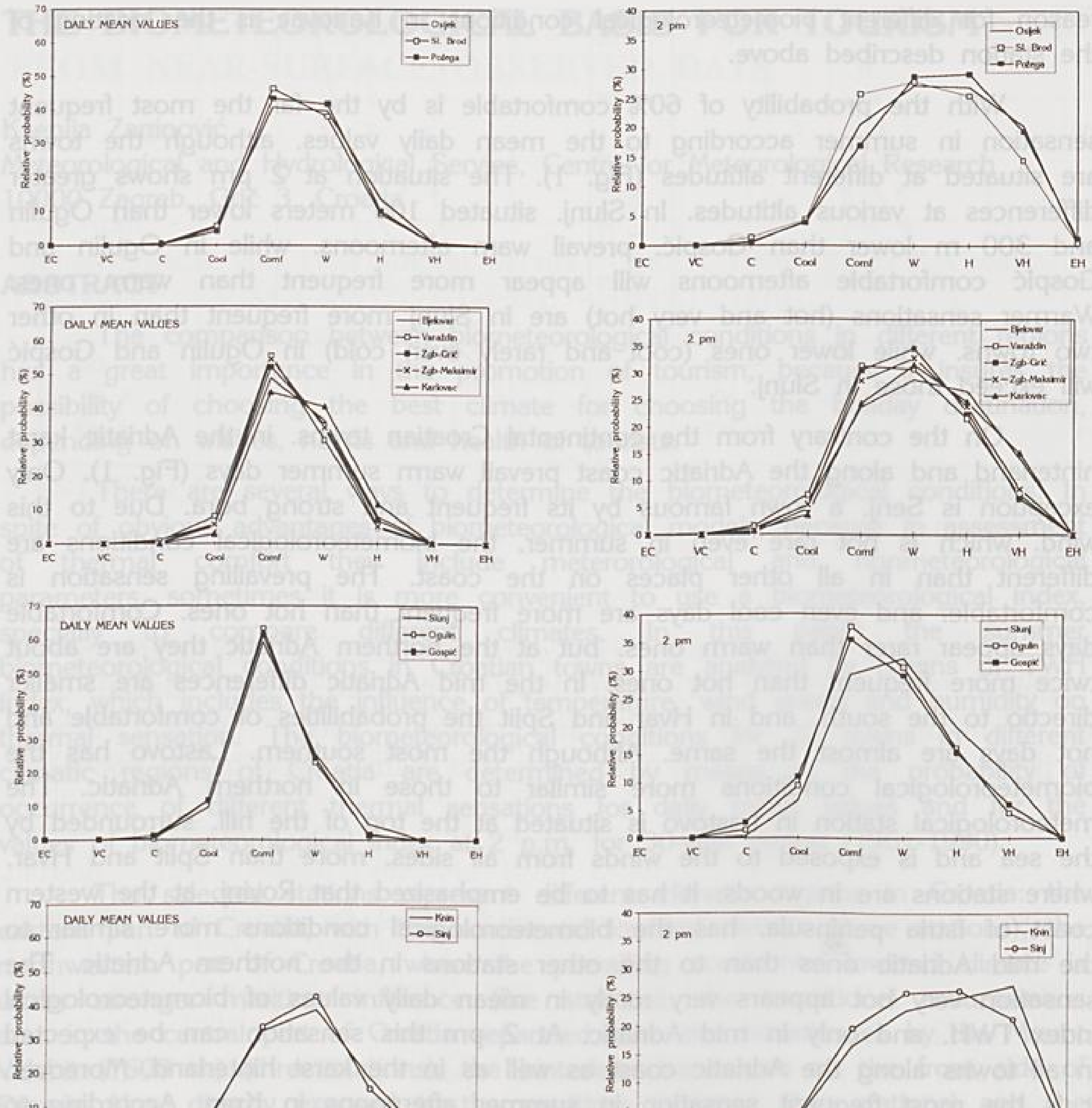

Figure 1. Distribution of thermal sensation in various climatic regions of Croatia according to daily mean values (left) and at 2 p.m. (right). period 1961-1990.

METEOROLOGICAL FACTS AND ACCIDENTS ON HIGHT VOLTAGE TRANSMISION LINE NETWORK IN CROATIA

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ABSTRACT

During March 1993. and 1995. the overhead transmission lines was destroyed in Dalmatia by meteorological phenomenon. The meteorological analysis for that days showed the existence supercooled rain and at the same time the storm wind with wet snow imposing an additional load on long-distance transmission lines.

March, 27, 1993.

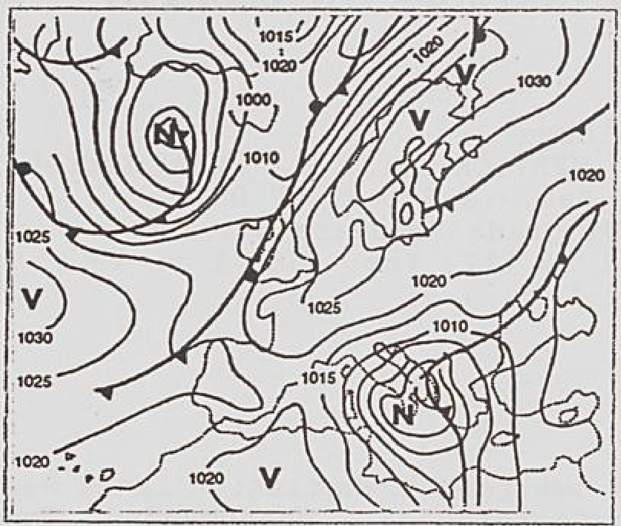


Fig 1. Surface pressure field, March, 27, 1993 at 00 UTC

The existencee of humid but rather cold air near the cyclone center resulted in a snowstorm in Dalmatia - unusual for this area and for this period of year. Meteorological analysis of that day showed existence rain which was frezing ehen touching the surface and in the same time storm wind occurred with wet snowing.

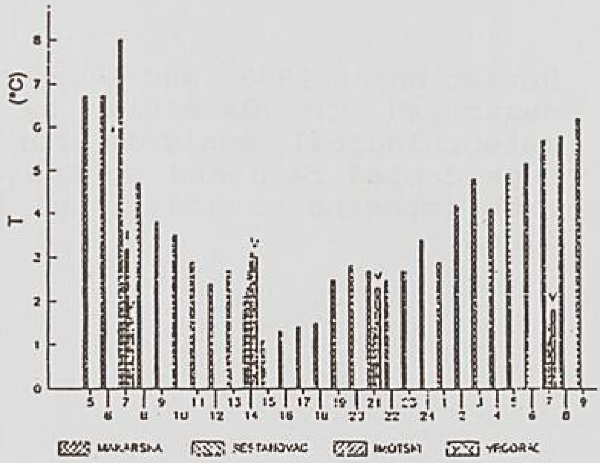


Fig.2. The daily pace of air temperature on March, 27-28, 1993.

In Dalmatia between Baška Voda and Ploče hight voltage transmission was destroyed.

Totally was destroyed 35 long distance transmission posts and partially it was damaged 10 long distance transmission posts. On 25 posts it was necessary to change some parts.

March, 27-28, 1995.

In a relatively short period from the nort-west Europe two cold air outbreaks propagated towards Croatia and resulted in two occurences cyclogenesis in the north Adriatic Sea. The snowfall covered even Dalmatia which is an extraordinary event for the last days in March.
Meteorological analysis of that days showed presence of storm wind occurred with wet snowing what was additional load on long distance transmission lines.

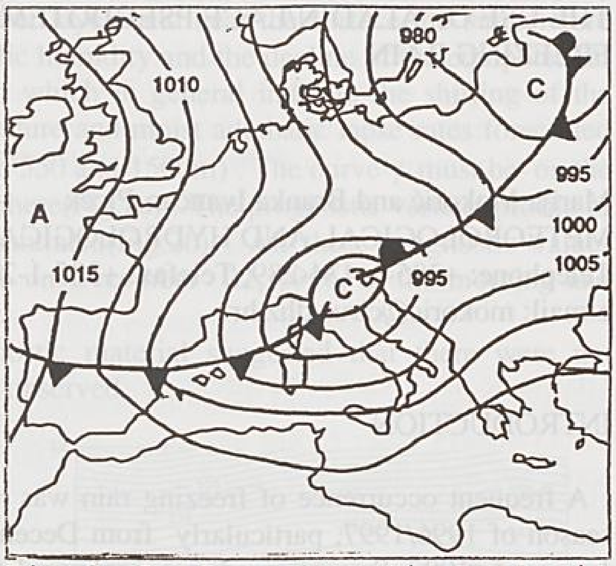


Fig.3. Surface synoptic analysis on March 28, 1995, 00 UTC

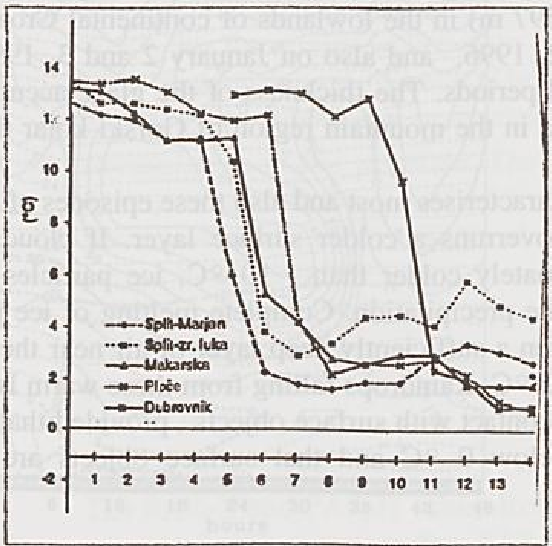


Fig.4. The daily courses of air temperature, South Croatia, March, 27-28, 1995

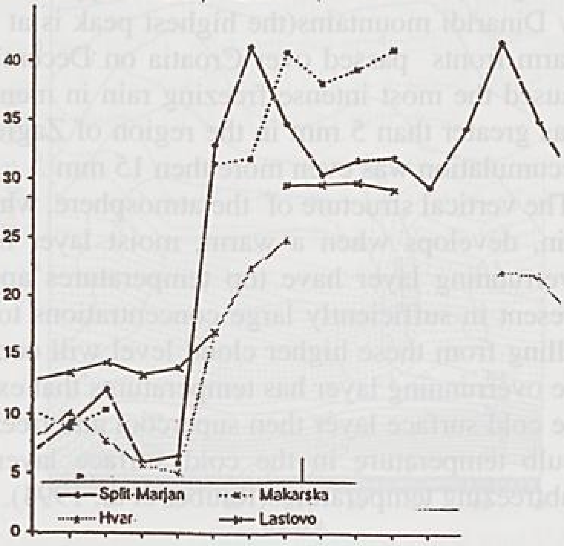
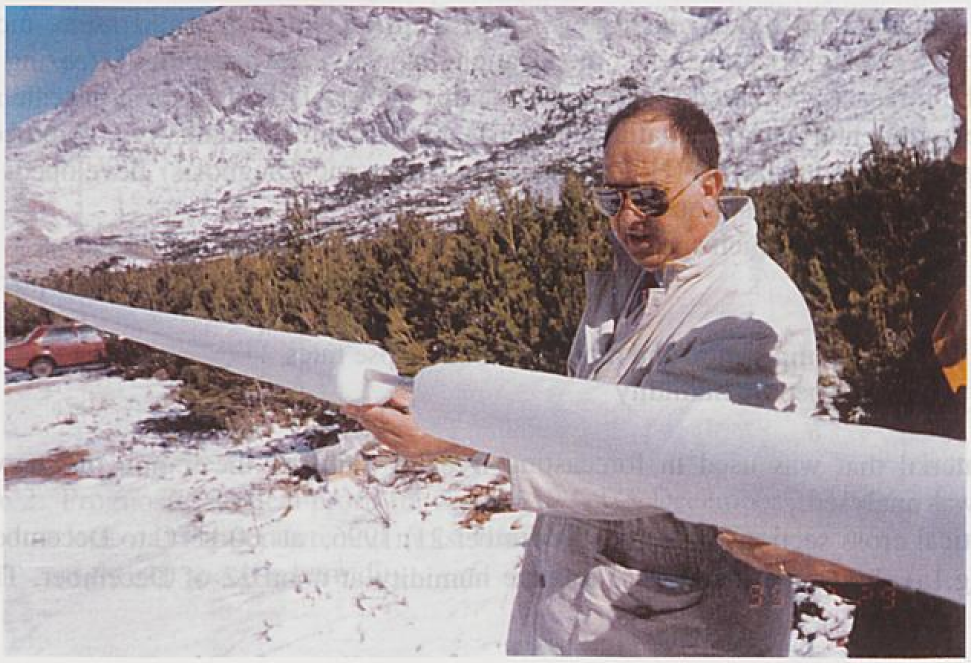


Fig.5. Maksimum wind gusts, South Croatia, March, 27-28, 1995.



It was similar situation like in March 1993. 34 long distance transmission posts was totally destroyed, 10 was partially damaged and on 24 posts it was necessary to change some parts.

THE USE OF ALADIN/LACE PSEUDOTEMPS IN FORECASTING FREEZING RAIN

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INTRODUCTION

A frequent occurrence of freezing rain was noticed in the continental part of Croatia in the winter season of 1996/1997, particularly from December 21 to December 24, 1996, and from January 1 to January 5, 1997. Synoptic and mesoscale analysis of these freezing rain events shows that there was a strong advection of warm air in the upper atmosphere and that in the same time cold air was held up by Dinaridi mountains(the highest peak is at the 1597 m) in the lowlands of continental Croatia. The warm fronts passed over Croatia on December 22, 1996, and also on January 2 and 3, 1997, and caused the most intense freezing rain in mentioned periods. The thickness of the glaze accumulation was greater than 5 mm in the region of Zagreb, and in the mountain region of Gorski kotar the glaze accumulation was even more then 15 mm .

The vertical structure of the atmosphere, which characterises most and also these episodes of freezing rain, develops when a warm, moist layer of air overruns a colder surface layer. If clouds in the overrunning layer have top temperatures approximately colder than - 10 °C, ice particles will be present in sufficiently large concentrations to initiate precipitation. Complete melting of ice particles falling from these higher cloud level will occur when a sufficiently deep layer of air near the base of the overrunning layer has temperatures that exceed 0 °C. Raindrops falling from these warm layer into the cold surface layer then supercool and freeze on contact with surface objects , provided that the wet -bulb temperature in the cold surface layer is below 0 °C and that surface objects are also at subfreezing temperatures(Rauber et al, 1994).

FORECASTING OF FREEZING RAIN

The forecasting of freezing rain is very difficult because a little change in temperature, moisture content and wind velocity can significantly affect the location, intensity, and duration of freezing rain. This winter season the forecast was based on the pseudotemps of ALADIN/ LACE mesoscale model for three points in the continental part of Croatia, in other words on their dynamically post-processing by applying the diagnostic model HRID (High Resolution Isentropic Diagnosis) developed by D. Glasnović . In forecast practise the most important were:

1. prognostic vertical cross-section which contains: a) relative humidity isoplets and isotherms
   b) equipotential temperature isoplets and specific humidity isoplets
2. prognostic vertical profile of temperature and moist-adiabatic lapse rates
3. prognostic vertical profile of specific humidity

The prognostic material that was used in forecasting freezing rain in the region of Zagreb for December 22, 1996, was analysed.

The prognostic vertical cross section valid from December 21, 1996, at 00 UTC to December 23, 1996, at 00 UTC (Fig.1a) shows the increase of relative humidity at noon 22 of December. The 0°-

isotherm was forecasted at 1000 meters and in the lower layers and near the surface the temperature was below 0°C. Figure 1b shows the increase of specific humidity and the decline of the equipotential temperature isoplets at noon 22 of December , 1996, which in general indicate the shifting of the frontal zone. The prognostic vertical profile of temperature and moist adiabatic lapse rates forecasted the inversion in upper layer of the atmosphere(between 550 and 1500m) . The curve γ must be on the left side of the dashed vertical line in the stable atmosphere(Fig.2a) . The prognostic vertical profile of specific humidity forecasted that the air would be saturated(Fig.2b). All these prognostic values suggested that the freezing rain may occur in Zagreb on December 22, 1996, in the morning and noon.

For another point (Osijek) the same kind of prognostic material suggested that there were not conditions for freezing rain, and freezing rain was not observed.

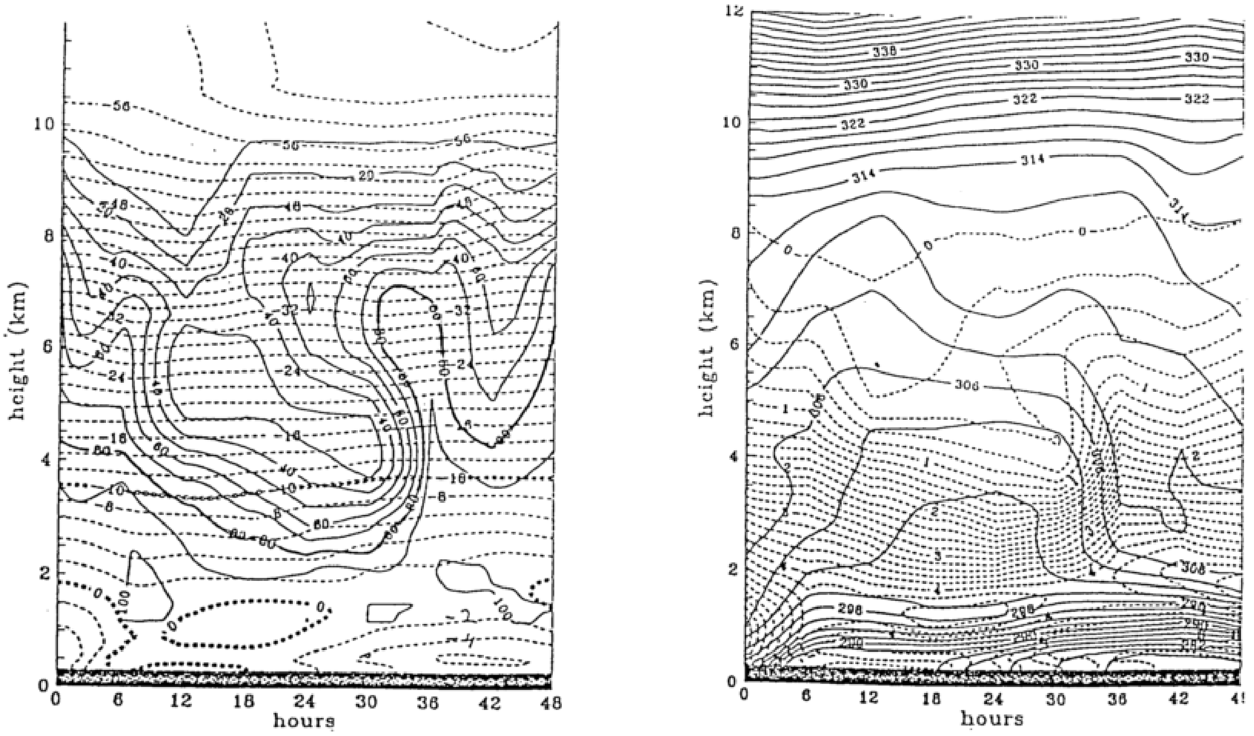

Figure 1 Prognostic vertical time cross-section for Zagreb, valid from December 21, 1996, 00 UTC to December 23, 1996, 00 UTC :
left a) relative humidity isopleths (solid lines) , isotherms (dashed lines)
right b) equipotential temperature isopleths (solid lines), specific humidity isopleths (dashed lines)

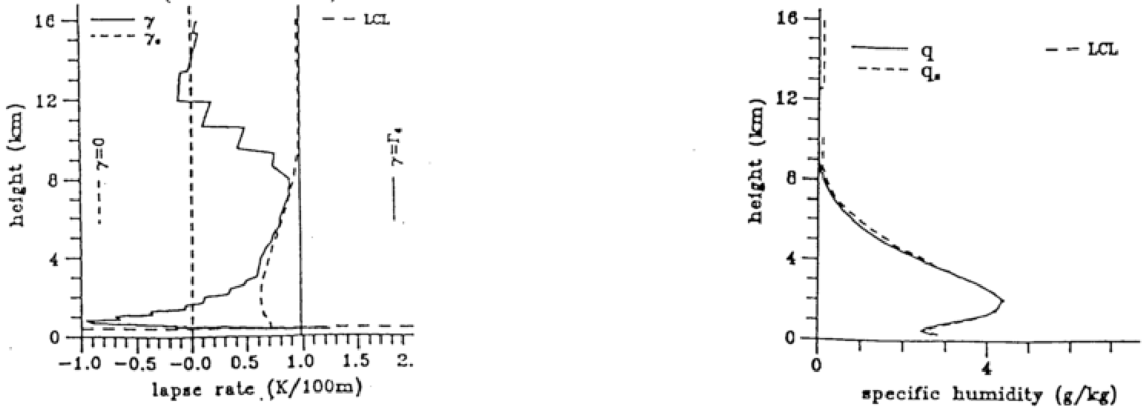

Figure 2 Prognostic vertical profil for Zagreb 12 UTC, December 22, 1996, of :
left a) temperature and moist-adiabatic lapse rates
right b) specific humidity

CONCLUSION

The analysis shows that ALADIN/LACE mesomodel correctly forecasted the passage of warm front and the vertical structure of the atmosphere near point Zagreb and Osijek on the days when freezing rain was occurred. Also it was shown that HRID results give good temporal and spatial distribution of meteorological variables which are most important for the beginning of freezing rain.

LITERATURE

Glasnović, D., I. Čačić, N. Strelec, 1994: Methodology and Application of High Resolution Isentropic Diagnosis Model(HRID), Österrichishe Beiträge zu Meteorologie und Geophysic, Wien, 109-136

Rauber, R. M. , M. K. Ramamurthy and A. Tokay, 1994: Synoptic and Mesoscale Structure of a Severe Freezing Rain Event: The St. Valentine' s Day Ice Storm, Weather and Forecasting, Vol. 9, 183-208

COMPARISON OF MRL5 RADAR-BASED PRECIPITATION AMOUNT WITH PRECIPITATION AMOUNT REPORTED BY GROUND STATIONS.

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Introduction. At present the Czech Hydrometeorological Institute performs routine radar measurements by using two meteorological radar: the MRL5 radar Prague-Libus, and the Gematronik Doppler radar Skalky. The new C-band radar Skalky has run since December 1995. The MRL5 has proceeded X-band measurements in automatic regime since 1993. That is why the MRL5 data archive allows statistical processing of radar-based precipitation amounts calculated by time integration of radar reflectivity values. The research activity aims at finding the representation of the routine radar information, which fits the ground information as well as reasonable, and will be applicable in Czech Hydrometeorological Institute. The joint research project RADHYD is a good platform for using Swiss assistance to improve the interpretation of the Czech radar data.

Formulation of the problem. The first results deal with the comparison of radar-based 12hr precipitation amount (PAR) with precipitation amount reported by the 56 ground stations located in the MRL5 radar field (PAS). The PAR and PAS values from the period V-IX.1994,1995 were considered. Maximum reflectivity, pseudo-CAPPI 1500m, and echo top measured by the radar MRL5 Prague-Libus are the input data set. Rain rate corresponding to the maximum reflectivity, and the pseudo-CAPPI 1500m was integrated to determine PAR-X, and PAR-H values, respectively. The PAR (PAR-X as well as PAR-H) values cover the area of 256x256 pixels (2x2KM) and correspond to the time period <06,18>UTC.

The PAR-X and PAR-H values from the pixel that covers ground station location were compared with corresponding PAS value. The statistical relation between PAR and PAS was described by correlation coefficient CC between lnPAR a lnPAS (CC[lnPAS,lnPAR]), and by RMSE between PAS and PAR (RMSE[PAS,PAR]). As awaited the results show the radar overestimation at the stations near radar position and underestimation at larger distance from radar. Besides the three Prague ground stations showed extreme high values of PAR as compared with PAS. That is shown in **Fig.1**, which depicts relative number of days (<06UTC,18UTC> periods) with nonzero PAS, PAR-X and PAS-H values.

Results. First attempt was made to improve the relation between ground and radar measured precipitation amount by applying multiple regression technique. We established regression equations by using predictor vectors with up to 24 components. Potential predictors were the PAR-X, and PAR-H values (1) from the pixel covering station location, (2) the maximum pixel value taken along the line connecting the radar position and the station location, (3) the mean pixel value calculated along the line, and (4) the distance of the pixel from the radar. The (2), and (3) values were determined without smoothing PAR values (pixel values) as well as with smoothing over the area 6x6KM (3x3 pixels).

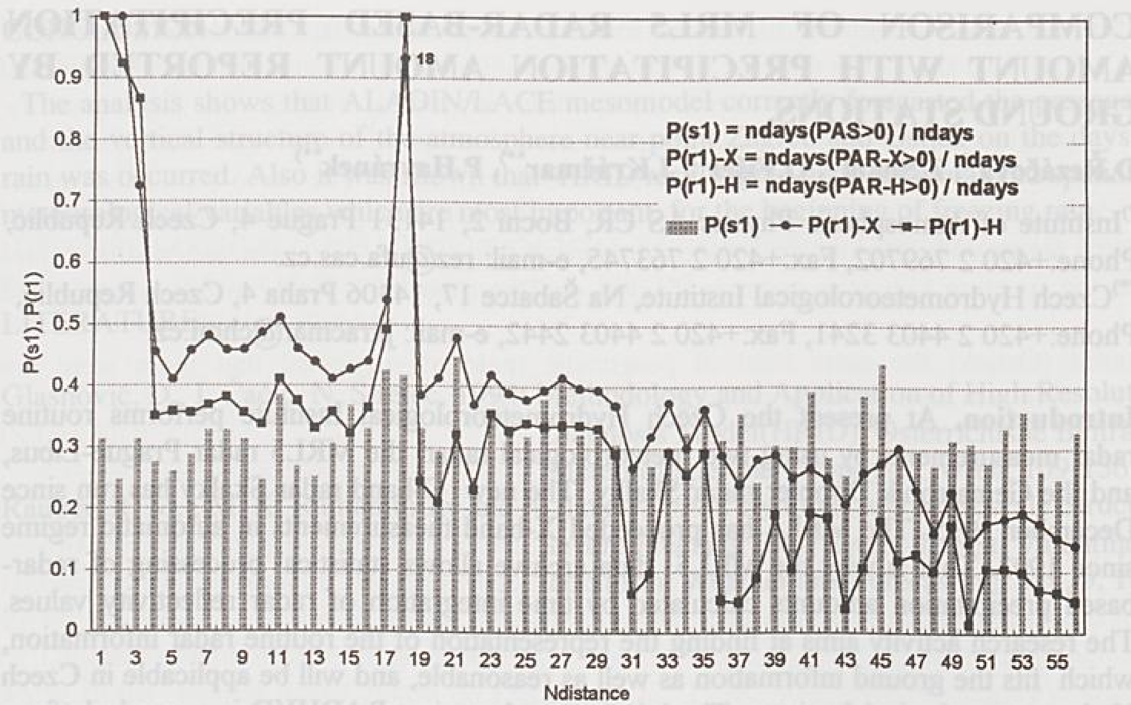

Fig.1: Relative frequency of <06,18> periods with nonzero precipitation amount reported by the radar, P(r1), and by the ground stations considered, P(s1). The stations were ordered according to the distance from radar (Ndistance).

Regression equations were determined (1) individually for each of the stations considered (PARreg-s) as well as (2) globally based on the whole set of station measurements (PARreg-a). The accuracy of the resulting values PARreg was compared with the accuracy of PAR-X and PAR-H. To determine the global regression equation we used regression model based on the pseudoinversion technique, which takes into account the correlation between single predictors. The equation depends on 19 independent variables, 18 radar predictors together with the distance from the radar. The resultant equation was applied to the whole radar field. We only excluded the square of 10x10 pixels in the middle of the radar field as corresponding radar variables are contaminated by permanent ground clutter. First results showed that regression values reduced the PAR-X overestimation near radar as well as they enhanced the underestimated PAR-X values over distant pixels. There were higher CC values following from the multidimensional information, and substantially weaker dependence of CC on the distance from radar in comparison with CC based on single predictor (PAR-X, PAR-H). We suppose that the effect of attenuation could be at least partly reflected by the use of predictors related to the path between a given pixel and the radar position. **Fig.2** shows an example of routine representation of PAR-X as compared with the representation following from regression values PARreg-a.

The activity is going on with testing of the regression equation by the artificially generated data and by independent data set. Corresponding 1996 data processing is in progress.

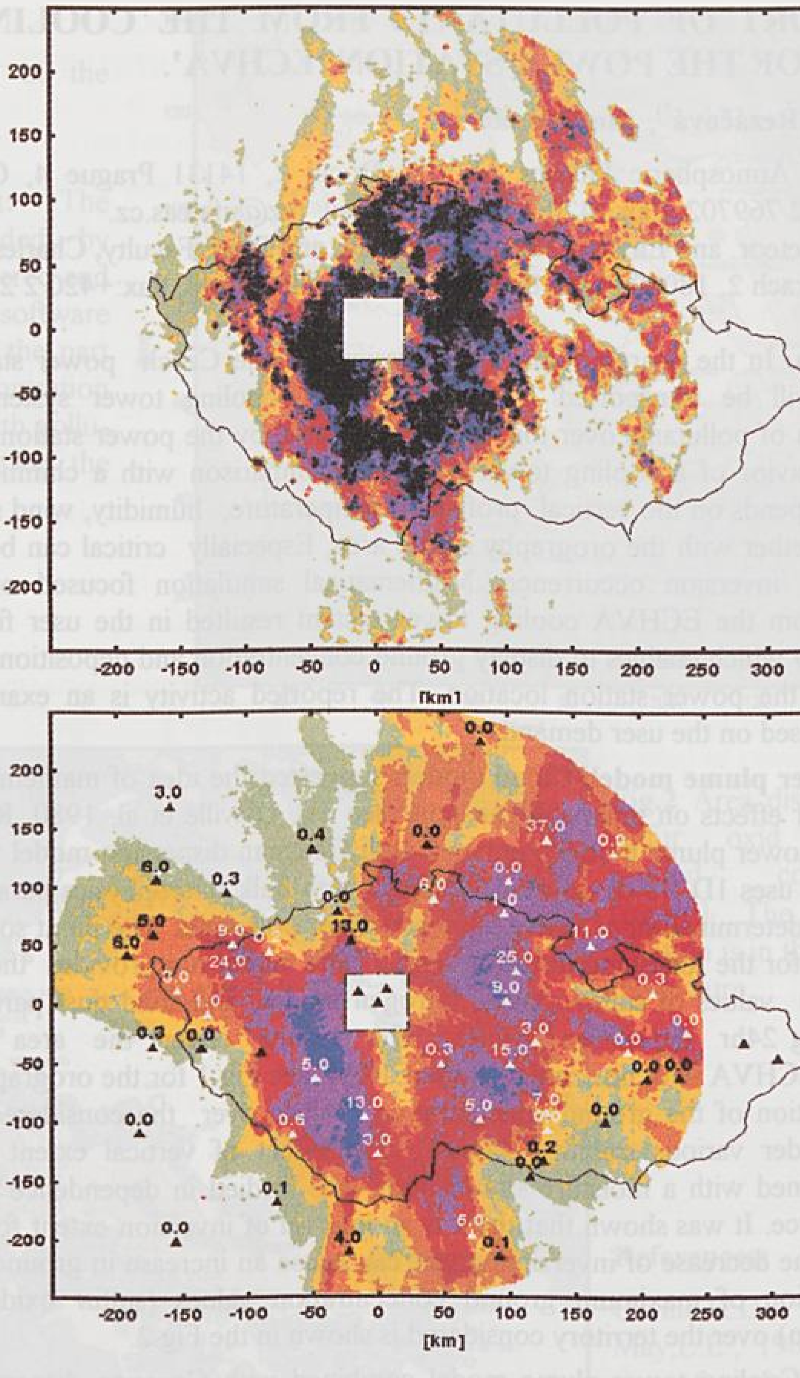

Fig. 2: Precipitation amount PAR(12,18) on 30.5.1995. Upper and lower pictures show the values of PAR-X and the values of PARreg-a, respectively. The ground station position and corresponding value of PAS are labelled in the lower picture. Colour scale: PAR[mm] = 0.5 (green), 1 (yellow), 2 (orange), 4 (red), 8 (magenta), 16 (blue), 32 (dark blue).

Acknowledgement: The activity is a part of the project RADHYD supported by the Swiss National Science Foundation. The authors express many thanks to the project head Dr.Juerg Joss for his useful constructive criticism and a large general assistance.

TRANSPORT OF POLLUTANTS FROM THE COOLING TOWER SYSTEM OF THE POWER STATION 'ECHVA'.

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Introduction. In the nearest future the emissions of the Czech power station Chvaletice (ECHVA) will be transported by the ECHVA cooling tower system. The ground concentration of pollutants over the territory affected by the power station can reflect the different behavior of a cooling tower plume in comparison with a chimney plume. The difference depends on the vertical profiles of temperature, humidity, wind speed, and wind direction together with the orography of the area. Especially critical can be the cases with temperature inversion occurrence. Mathematical simulation focused on the pollutant dispersion from the ECHVA cooling tower system resulted in the user friendly software ECHVAKOD which enables to display ground concentration and deposition values over the area around the power station location. The reported activity is an example of applied research focused on the user demands.

Cooling tower plume model. Cloud models suggested the idea of mathematical modelling cooling tower effects on pollutant transport (see e.g. Orwille et al. 1980, Rezacova 1988). The cooling tower plume model combined with Gaussian dispersion model was formulated. Plume model uses 1D SS cloud model scheme with bulk microphysics parametrization and results in the determination of fictive point source of pollutants. The point source parameters are the input for the following diffusion model. The model run provides the 30min ground concentration values of sulfur oxides, nitrogen oxides, and solid dust particles as well as corresponding 24hr deposition values. The results cover the area of 140x140KM around the ECHVA with horizontal step of 1KM (see Fig.1 for the orography of the area). The distribution of the ground concentration values over the considered territory was examined under various stability classes. The effect of vertical extent of temperature inversion joined with a moisture stratification was studied in dependence on the distance from the source. It was shown that there is an interval of inversion extent for every stability class where the decrease of inversion extent can cause an increase in ground concentration. The distribution of maximum ground concentration values (sulfur oxide emitted after desulfurization) over the territory considered is shown in the Fig.2.

Conclusion. Cooling tower plume model combined with Gaussian dispersion model was used to examine the ground concentration of ECHVA pollutants. The model was implemented into a user-friendly software product ECHVAKOD to enable graphic display of the resulting ground concentration and deposition fields given the actual input data. Airborne measurements of cooling tower plume extent will be made in autumn 1997. The results will be used to the improvement of model parameter values. The presented activity is the result of the collaboration between IAP AS CR and Math.Phys.Fac.Ch.U.

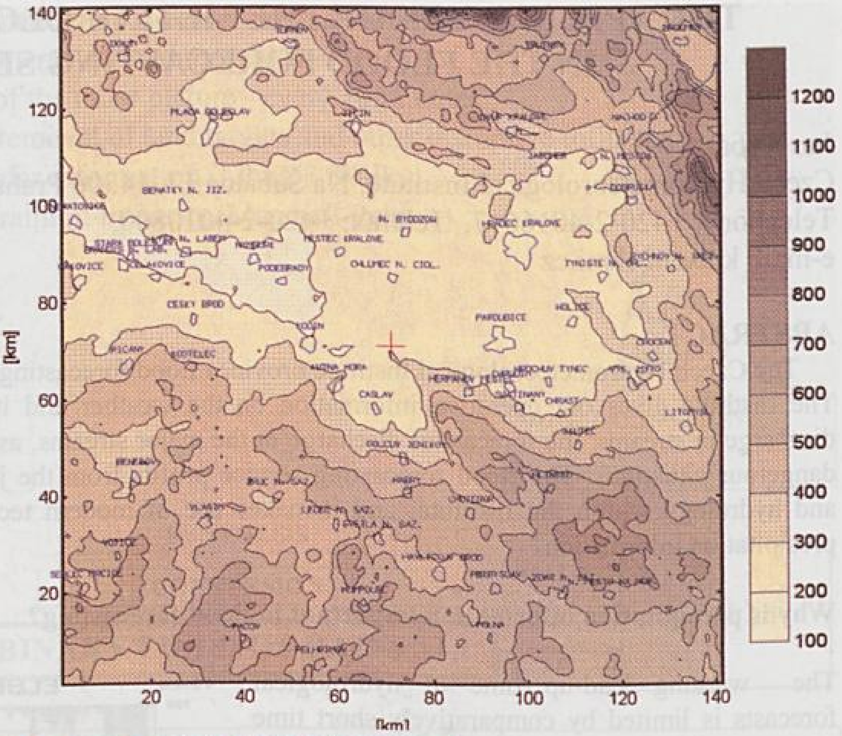

Fig.1 Orography of the area of interest.

Acknowledgment: The activity was funded by the firm ESV Liberec and the resulting software product will be the part of the firm information system dealing with pollutant dispersion over the ECHVA territory.

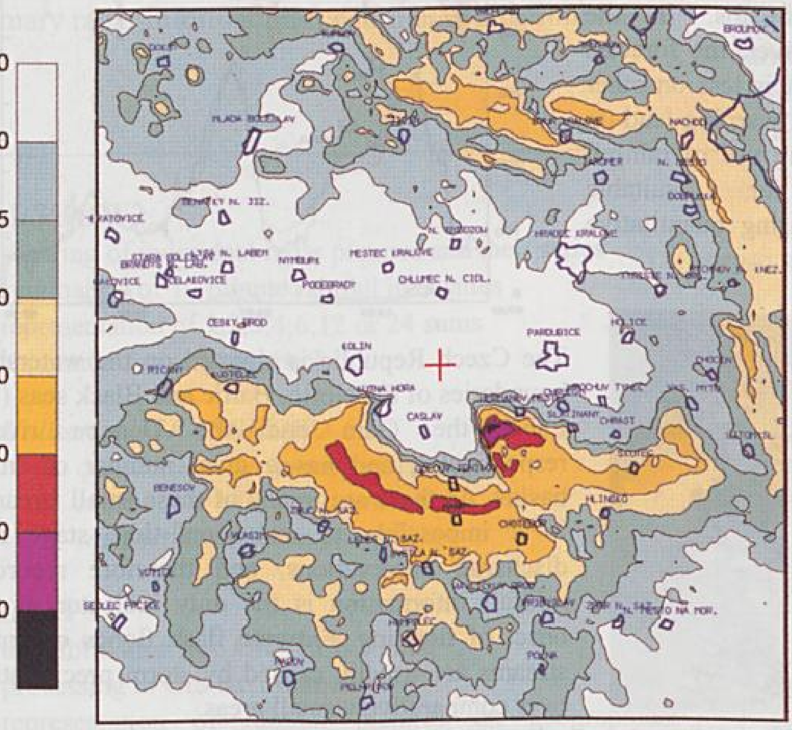

Fig.2 Area distribution of sulfur oxid maximum ground concentration [$\mu g/m^3$]. The ECHVA location is in the middle of the picture.

References:

Orville,H.D., Hirsch,J.H., May,L.E., 1980: Application of a cloud model to cooling tower plumes and clouds. J.Appl.Meteor.,19, 1260-1272.

Rezacova,D.,Novakova,A. , Kulik,J., 1988: Simple mathematical model of the plume from the cooling tower system. 1. Model description and first experience (in Czech). Meteorol.Zprávy 41,12-16.

THE APPLICATION OF THE METEOROLOGICAL RADAR IN THE FLOOD FORECASTING SERVICE

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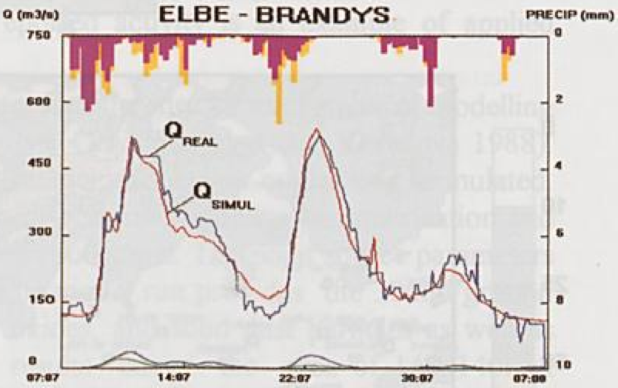
ABSTRACT

The Czech Hydrometeorological Institute provides flood forecasting service in the Czech Republic. The Institute gives out operative information on the weather and its forecasts, on the stage and discharge in streams, the forecast of discharge in the major streams, as well as alerts and warnings of dangerous situations. The flood forecasting service profits from the joining of applied meteorology and hydrology within the Institute, and it makes use of modern technology for the evaluation of precipitation information.

Why is precipitation information important in flood forecasting?

The warning lead-up time of hydrological forecasts is limited by comparatively short time of concentration of the streams. In the downstream part of the Labe river, the forecast lead-up time is 24 hours, and it is less on other streams. The lengthening of the warning lead-up time is only possible by making use of rainfall information as input data for a suitable hydrological model and by using quantitative rainfall forecasts.



The Czech Republic is situated on the watershed boundaries of the North, Baltic and Black seas (the Labe, the Odra and the Danube rivers, respectively), and has a great number of small basins. As there are many of these small streams, it is impossible to make real-time stage and discharge observations, and therefore recorded rainfall information is the only indicator of the onset of flooding. Extreme flash floods on small streams are usually caused by storm precipitation over comparatively small areas.

The meteorological and hydrological forecasting service receives precipitation information from:

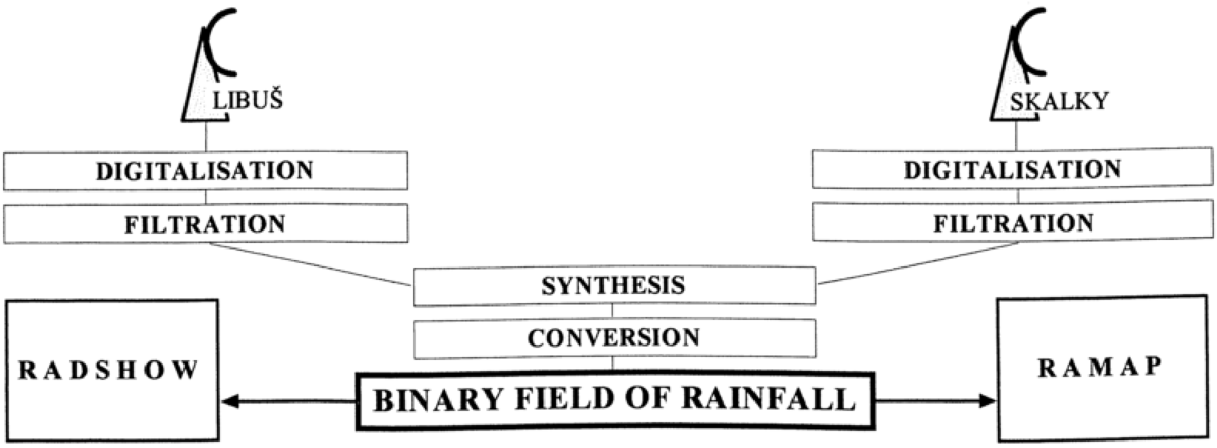
- 35 professional meteorological stations (after 6 hours),
- 108 volunteer climatic stations (after 24 hours)
- 85 volunteer hydrological stations (after 24 hours)
- 2 meteorological radars

⇒ Praha - Libuš type MRL-5/WRP-32C
⇒ Skalky (central Moravia) type GEMATRONIC Meteor360AC

Rainfall information is evaluated at a central continuously manned head office in Prague. This office gives out rainfall data, forecasts and warnings. The Institute has further six regional offices, which provide forecasting and flood warning service within their respective regions.

Methodology of Radar Information Processing and Evaluation

- radar measurement - interconnected
- digitalisation of the radar picture - every 10 minutes
- filtration (the removal of land targets and other disruptive influences)
- synthesis of radar information (Libuš + Skalky)
- conversion to rainfall intensity (Marshall-Palmer) .



Primary radar information for further evaluation:	**binary field of rainfall** rainfall intensities (mm/hour) in a time step of 10 minutes 2x2 km pixels

RADSHOW2

- showing of individual radar pictures and their series
- summation of 10 minute rainfall intensities
- representation of 1,2,3,4,6,12 or 24 sums
- animation forward and back

Utilisation of RADSHOW2

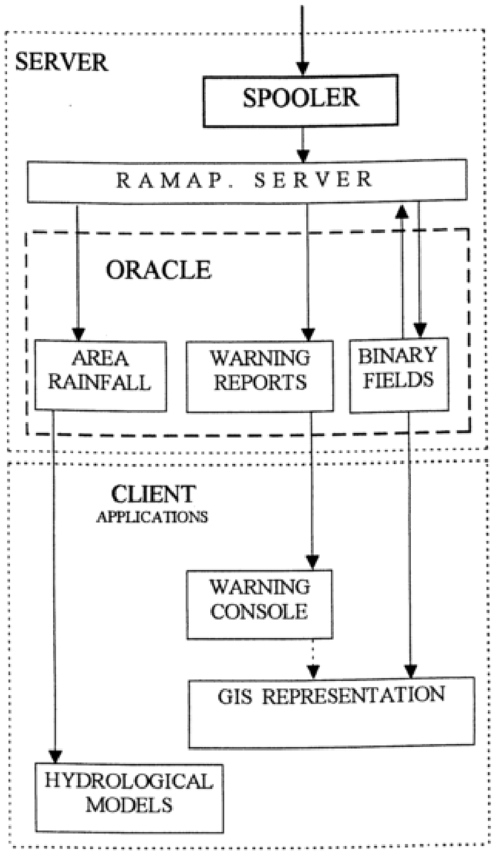
- *quick and wide-spread information*
- *reasonable hardware demand*
- *Internet distribution possibilities*

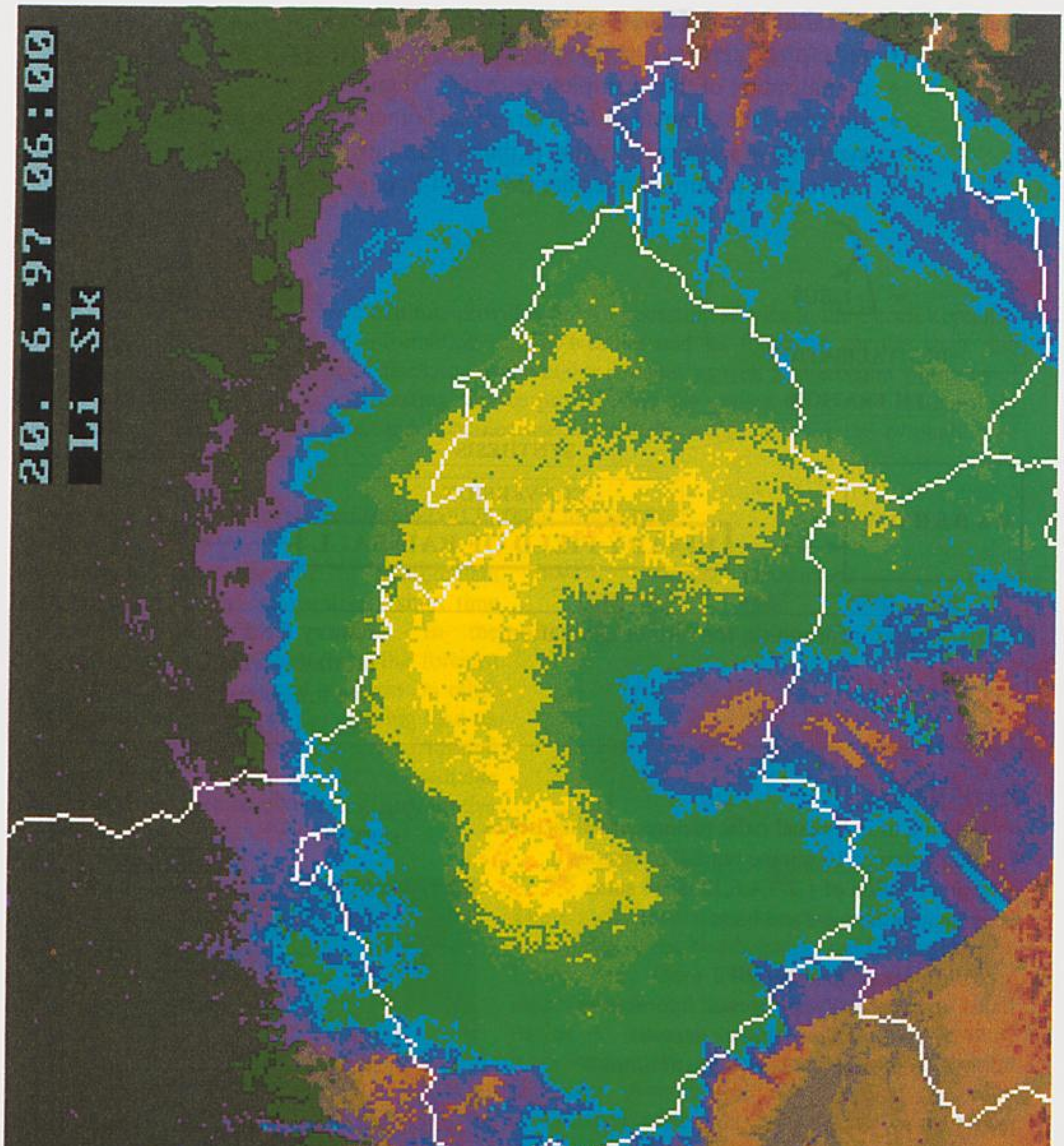
RAMAP

- transformation into ORACLE format
- processing in GIS environment
- representation of rainfall pictures on geographical background
- automatic evaluation of alert levels
- providing of warning reports
- calculation of area rainfall in given space and time

Utilisation of RAMAP

- *special information for flood forecasting service*
- *automatic extreme rainfall warning system*
- *rainfall inputs for hydrological models*

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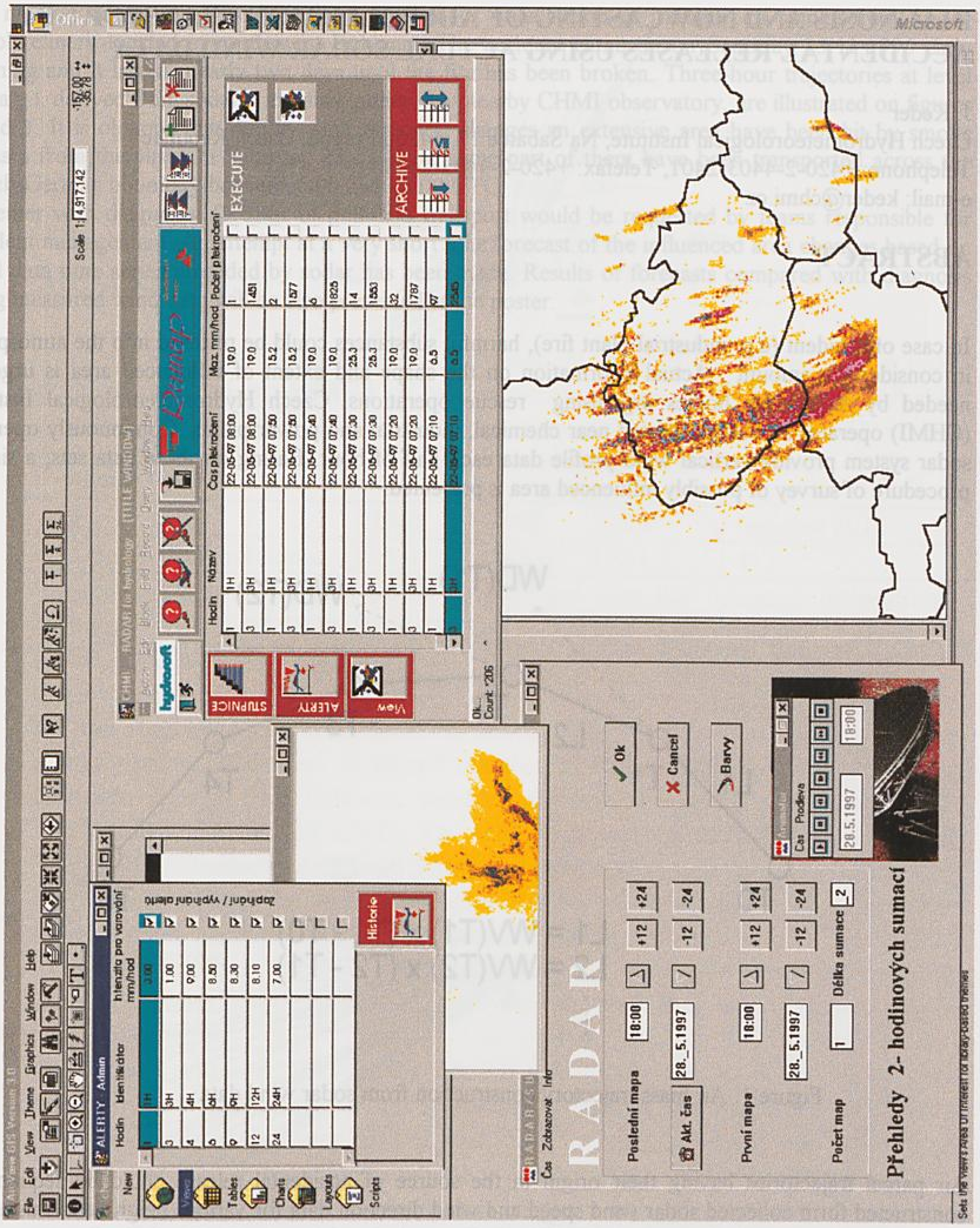
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View

DIAGNOSIS AND NOWCASTING OF AIR POLLUTION TRANSPORT BY ACCIDENTAL RELEASES USING ACTUAL SODAR WIND DATA

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ABSTRACT

In case of accident (e.g. industrial plant fire), harmful substances could be released into the atmosphere in considerable amount . Actual information on the shape and extent of influenced area is urgently needed by responsible bodies organising rescue operations. Czech Hydrometeorological Institute (CHMI) operates six sodars located near chemical, industrial and power plants. Continuously operated sodar system provide vertical wind profile data each half of hour. Basing on these data sets, a simple procedure of survey of possibly influenced area is presented.

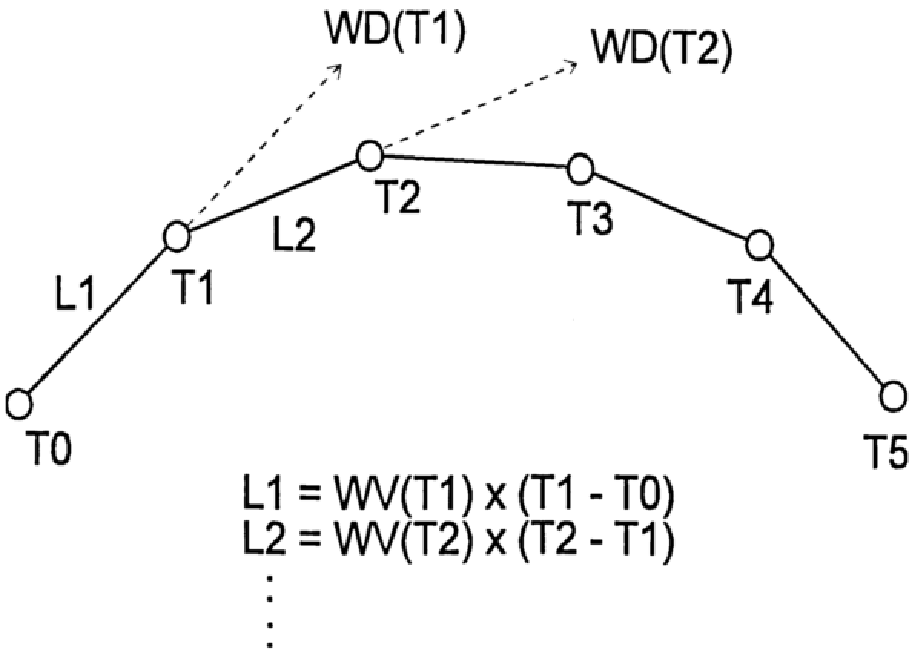

Figure 1: Air mass trajectory construction from sodar wind data

Air parcel trajectories having their origin in the source of accidental release could be sequentially constructed form collected sodar wind speed and wind direction data for various height levels using the procedure schematically demonstrated on Fig. 1. For each time interval $(T_i\ ,T_{i+1})$, the line segment of the trajectory of length $L_{i+1} = WV_{i+1} * (T_{i+1} - T_i)$ and with direction corresponding to WD_{i+1} could be plotted. Here WV_{i+1} and WD_{i+1} are mean wind velocity and wind direction derived from sodar measurements during time period $(T_i\ ,T_{i+1})$. Each hour or half-of-hour, a new trajectory could be started from the accident site. Trajectories should be terminated after some reasonable time elapsed, e.g. 3 hours. A shape and an extent of the area possibly stricken by pollutants could be derived form the resulting trajectory field.

The method described above have been applied for visualisation of transport of smoke from fire of petrol refinery located in north-west Bohemia. The accident came on on Saturday 23.11.1996 early morning and it lasted nearly two days until the fire has been broken. Three-hour trajectories at level 500 a.g.l, derived from sodar wind data gathered at nearby CHMI observatory, are illustrated on figures 2 and 3. It is obvious that due to wind direction changes an extensive area have been hit by smoke releases from this fire. On Saturday 23.11.1996, some part of them have been transported across the Czech-German boundary between 6:00 and 16:00 UTC.

Together with diagnosis, forecast of pollutant transport would be requested by teams responsible for accident management. An attempt at a very short time forecast of the influenced area changes based on wind data time series provided by sodar has been made. Results of forecasts compared with diagnosis using measured wind data will be also presented at the poster.

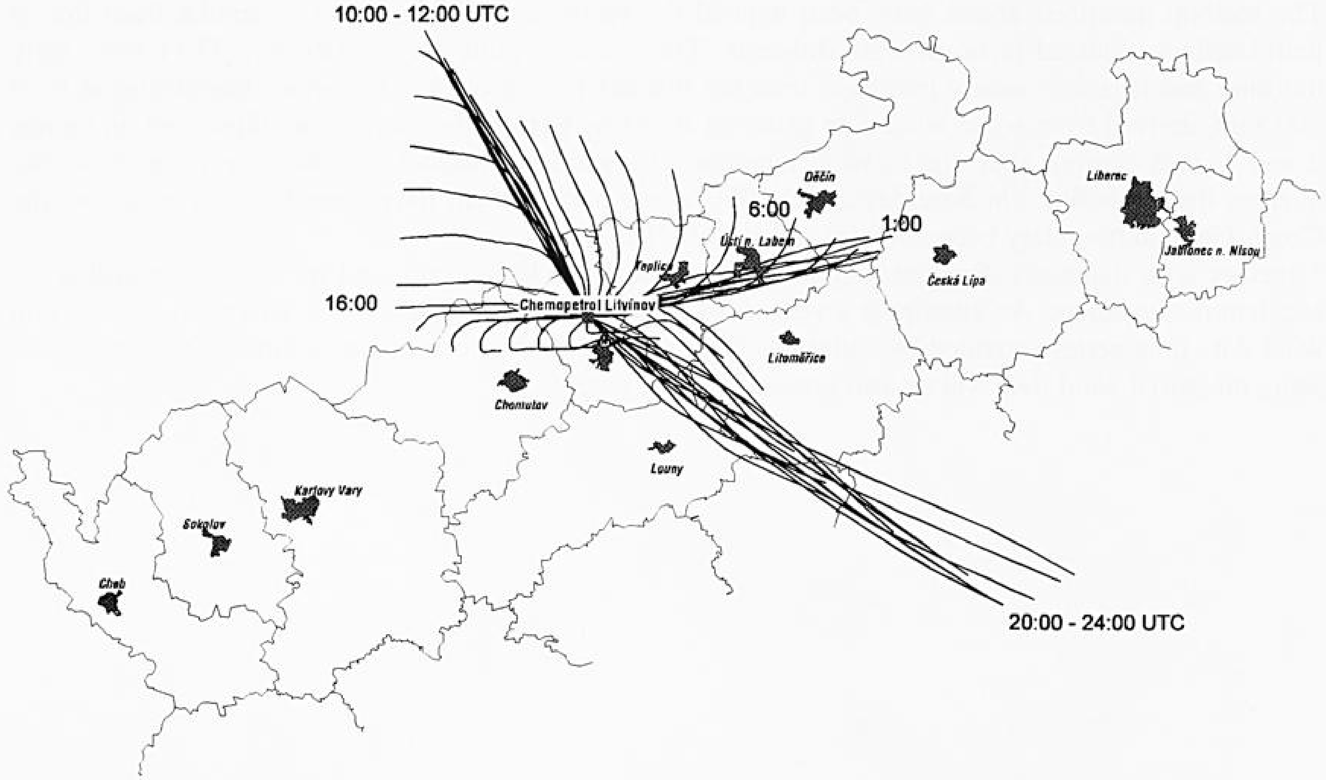

Figure 2: Three-hour forward trajectories demonstrating transport of air masses polluted by industrial accident (refinery fire) in north-west Bohemia, 23. 11.1996

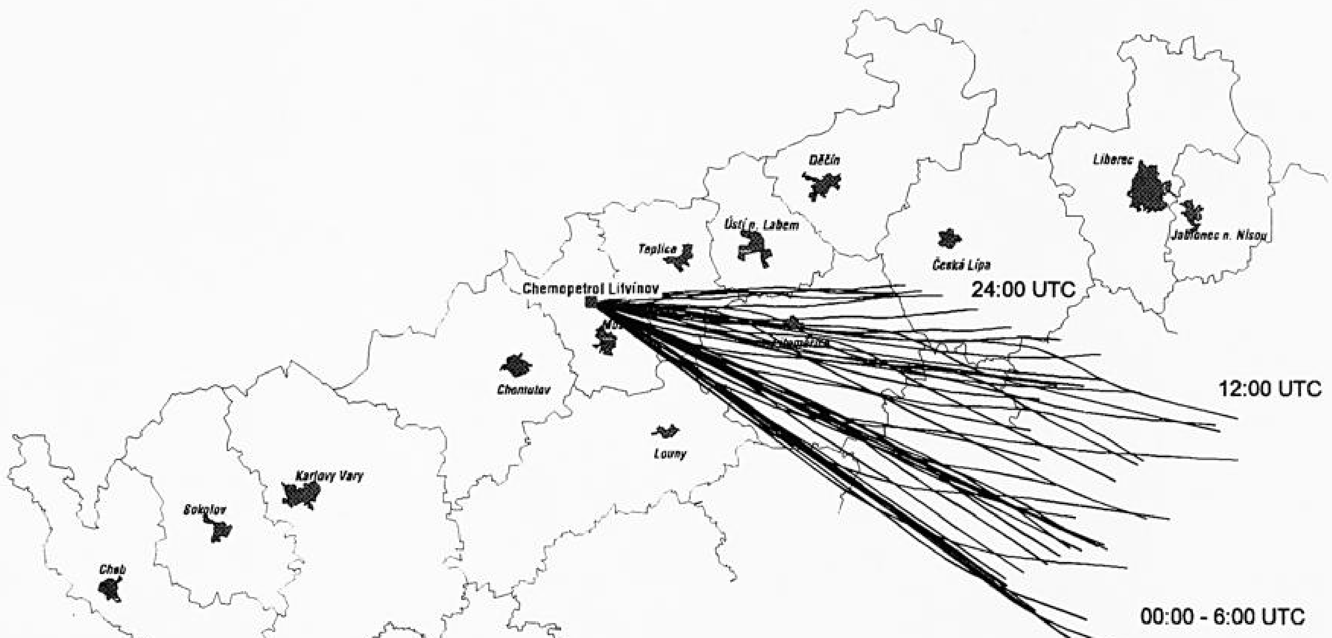

Figure 3: Three-hour forward trajectories demonstrating transport of air masses polluted by industrial accident (refinery fire) in north-west Bohemia, 24. 11.1996

ROAD METEOROLOGY - A NEW TASK IN ESTONIAN METEOROLOGICAL AND HYDROLOGICAL INSTITUTE

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ABSTRACT

From 1991 , since Estonia became independent republic again, there have been great changes in every field of human activity. One of the most remarkable change is the growing amount of cars on Estonian roads. The data of Estonian Road Administrations (ERA) shows this increase as follows

year	1965	1990	1997	forecast 2010
cars/per 1000 inhabitants	33,5	268,6	331,1	412

The current rate of growth traffic density and also the planned international highway VIA BALTICA from Finland to Central Europe arises a need for special road weather forecast.

Since January 1996 EMHI is providing road weather forecasts for ERA and also for the road cleaning companies in towns Tallinn,Tartu,Narva. Forecasts for winter season 1996 were produced mainly on the basis of real time data from Northern Europe and Estonian weather stations and using numerical model HIRLAM, ECMWF and DWD. The last winter season from 15th October till 30th April addiotional data from 3 road weather stations (Figure 1) were in use. Next few years amount of road weather station will grow up to 22, almost the same number as nowadays existing weather station in Estonia (23). These data from road weather station will be estimated and compared with nearby lying weather station. The first brief analysis showed that these data a quite representative.

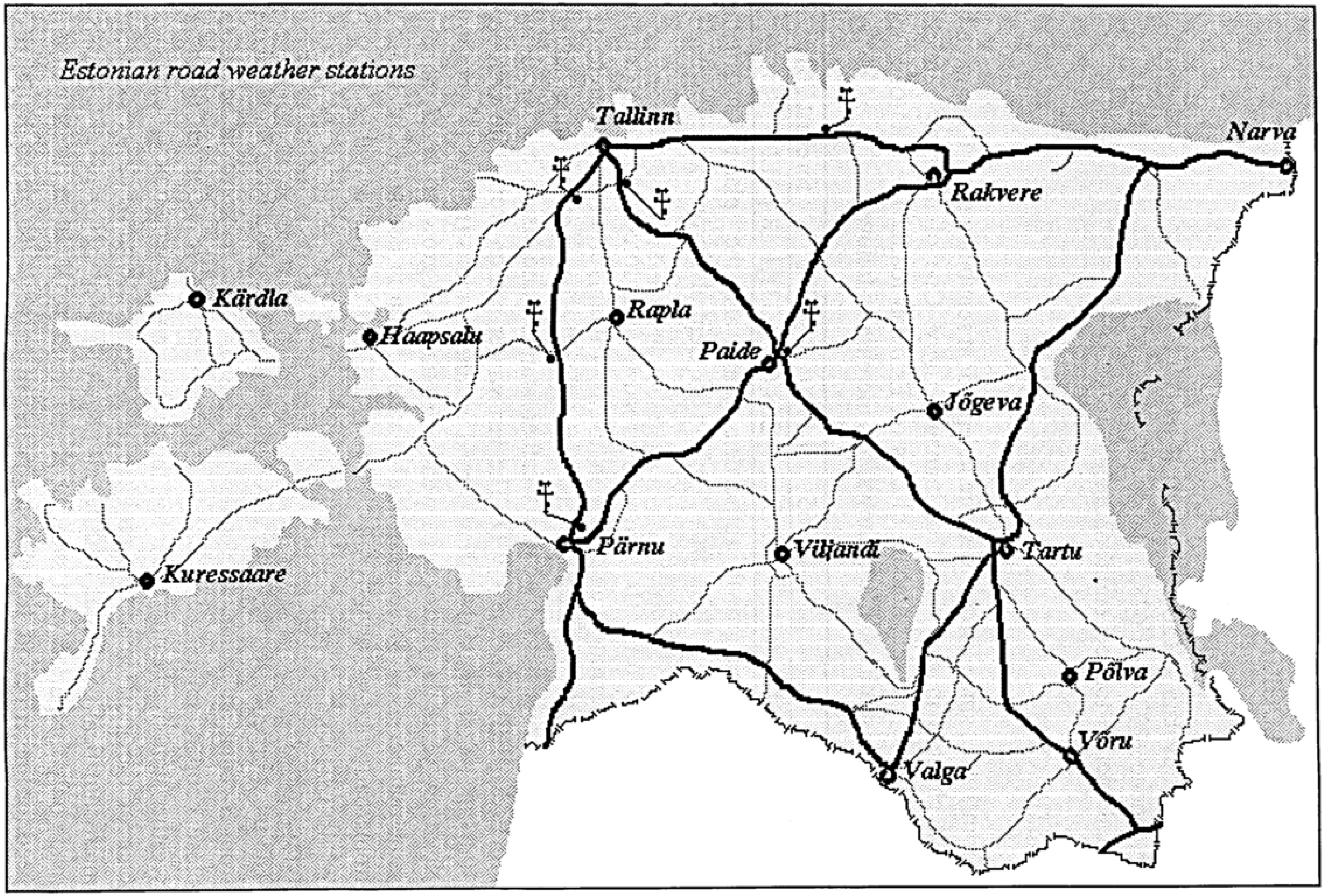
The most urgent need is to install weather radar, today we have only radar data from Sweden and Finland over the Baltic Sea. Our attention will be also very close cooperation between EMHI and ERA in the development of the road weather stations, weather radar and the process and presentation systems.

One of the most important problem is how to use previous research about microclimatical conditions in different parts of Estonia. Nowadays forecasts are made only for period with snow or sleet (Figure 4,5), but in future will arise a need for longer period, because the mean value of duration of the period without frost in low places is only 90-110 days. There are heavy night frosts until June and sometimes ground frosts start already in August (Figure 2,3).

EMHI will have a long way ahead to take over the knowledge already existing in this field of meteorology .

References: Highway Meteorology edited by A.H.Perry and L.J.Symons ,1991

FIGURE 1



ERA, 1997

FIGURE 2 THE LAST NIGHT FROST IN THE AIR

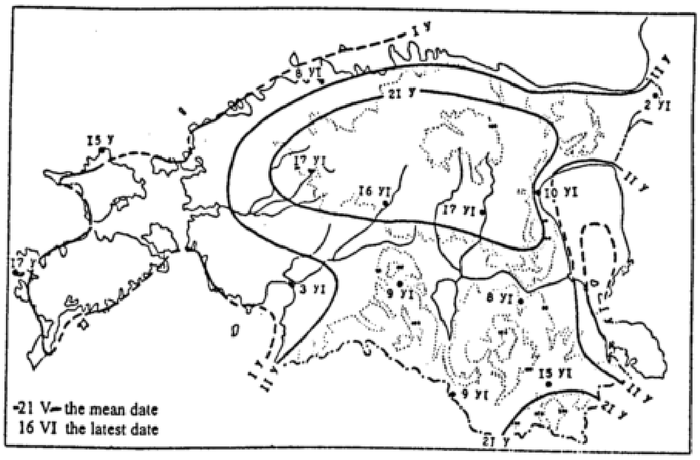


FIGURE 3 THE FIRST NIGHT FROST IN THE AIR

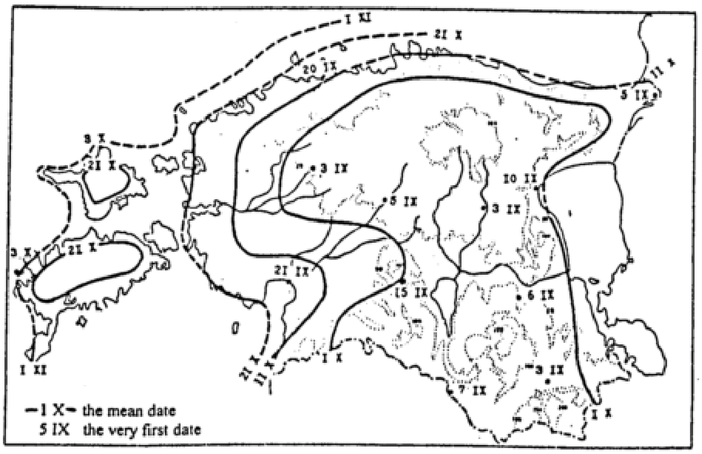


FIGURE 4 THE AVERAGE AND EARLIEST DATE OF APPEARANCE
THE FIRST SNOW COWER

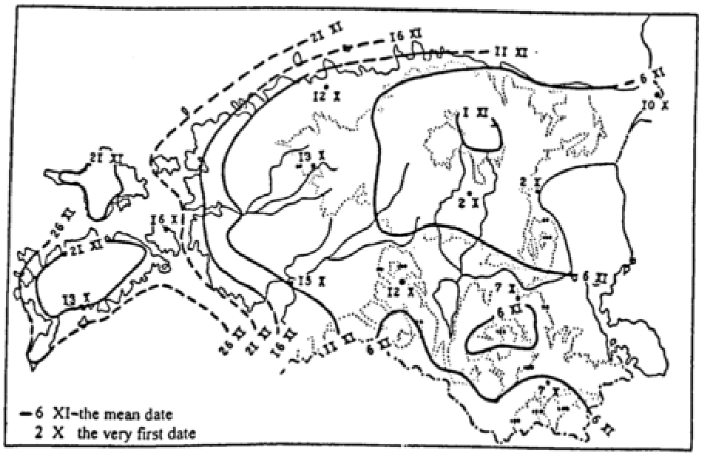
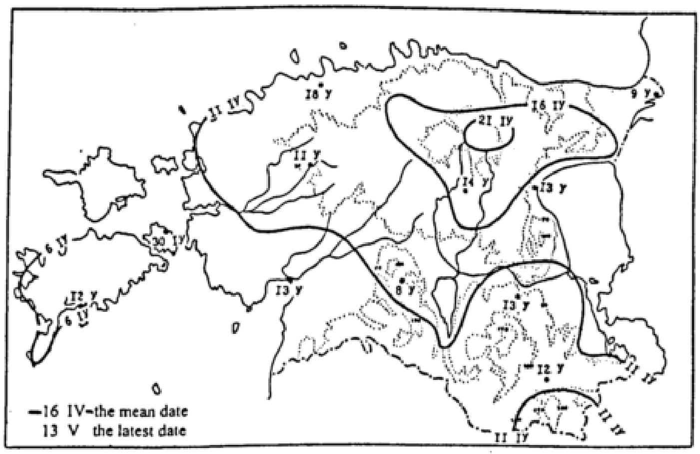


FIGURE 5 THE AVERAGE AND LATEST DATE OF DISAPPEARANCE
THE SNOW COVER



EESTI KLIIMAATLAS
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Making low level significant weather chart in the Hungarian Meteorological Service

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ABSTRACT

In the last five-seven years the number of VFR flights increased extensively in Hungary, and the technical basis of the Aviation Meteorological Centre of the Hungarian Meteorological Service (HMS AMC) developed extensively too. So we could develop computer algorithms for making low level significant weather charts using not only terminal aerodrome forecast (TAF) data, but data of NWP models too.

In the Hungarian Meteorological Service we made low level significant weather charts since the 80's. On the charts we predict the next data: Position and type of fronts; amount, top and base of clouds; extent of turbulence and icing; state and type of precipitation; height of 0 °C layer, visibility range; windflags on 5000 feet. Sometimes we give warnings for mountain waves and strong winds (windspeed of gusts greater than 40 knots).

For making these products earlier we used only TAF data. At present time (since June 1997) we use the data of ALADIN (Aire Limitee Adaptation Dynamique Developpement International) mesoscale NWP model, some data of UKMO LAM (United Kingdom Met. Office, Limited Area Model) and the Middle-European TAF messages. Our future plan is using only ALADIN and TAF data.

We calculate the next aviation meteorological elements using data of the above mentioned NWP models : Windflags on 5000 feet, lifting condensation level, amount of clouds, visibility in precipitation, icing, turbulence, height of 0 °C layer, state and type of precipitation, the probability of thunderstorm, $\nabla^2\Theta_{ps}$ on 850 hPa level (the Laplace of pseudo potential temperature).

We calculate the lifting condensation level and cloud base from ALADIN pseudo-temp (predicted vertical profiles of wind, temperature and humidity) and TAF data.

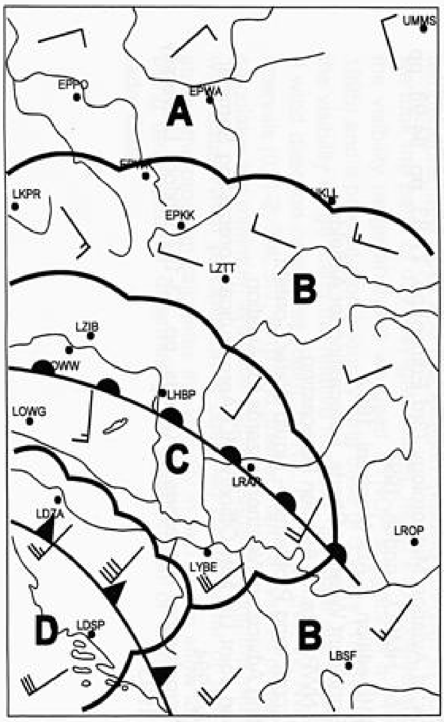
The amount of clouds is determined by the predicted relative humidity for six levels (500, 1000, 1500, 2000, 3000 and 5500 m). The lowest two levels is usable in winter time, when the stratus clouds are situated below 1000 m. The limits of relative humidity for the same amount of clouds are different for daytime and nighttime hours, for winter, summer and spring-autumn seasons, and they are different in different levels.

At present time we use the TAF data for the forecast of visibility range and a single equation for the forecast of visibility in precipitation.

Visibility (in m) = $a*x^b$, where x, the precipitation intensity in mm/h, a>0 and b<0 (a and b are different for rain and snow). A new method is being developed for the estimation of visibility range, based on pseudo-temp data.

The maximum-available icing is calculated from the temperature and relative humidity data of the lowest 3000 m.

FIXED TIME CHART VALID 12 UTC



SIGWX BELOW 10000FT
ISSUED BY
HUNGARIAN METEOROLOGICAL SERVICE
AV. MET. CENTRE AT 05 UTC

Note:
1. Pressure in hPa and speeds in knots.
2. Vis in m or km. Hills fog implies vis 200M or less.
3. Attitude in hectofeet above MSL   XXX=above 10000ft.
4. TS and CB imply MOD/SEV icing and turbulence

01. 01. 1997.   BASED ON 00 UTC DATA ON 01.01.1997.

VARIANT	VIS	WEATHER	CLOUD, TURBULENCE, ICING	0°C
AREA A	8	NIL	SKC	SFC
OCNL	3	BR	BKN ST, SC 005/055	
AREA B	5	BR	BKN/OVC ST, SC, AC 010/XXX	SFC
LOC	1.5	SN	OVC ST, NS 005/XXX	
LOC S	3	FZRA	OVC ST, NS 008/XXX	NSFC/050
LOC COT	3	RA	OVC ST, NS 010/XXX	050
AREA C	3	SN	OVC ST, NS 008/XXX	SFC
LOC	500m	+SN	OVC ST, NS 003/XXX	
LOC	5	BR	BKN SC, AC 020/XXX	
AREA D	5	RA	OVC ST, NS 015/XXX	050
OCNL N	2	SN	OVC ST, NS 003/XXX	SFC
LOC IN VAL	2	FZRA	OVC ST, NS 010/XXX	SFC/050
ISOL	2	SHRA, SHSN	EMBD CB 005/XXX	

WARNING AND/OR REMARKS:
- WIND ARROWS REFER TO 5000 FEET.

Figure 1. Low Level Significant Weather Chart of the HMS AMC

The lowest and highest levels of the 0°C (in the given gridpoint) are determined from ALADIN pseudo-temp data.

The maximum available low-level turbulence is calculated with a single decision algorithm using the windspeed data of ALADIN.

Five states of precipitation are distinguished by a numerical algorithm. These states are frozen (snow), liquid (rain), mixed (rain and snow), supercooled (freezing rain) and again frozen (ice pellets). These states are calculated from the position, thickness and average temperature of the positive and negative temperature layers.

Determining type of precipitation (convective, stratiform) we use the temperature difference between the 500 and 850 hPa levels (VT index).

For the estimation of probability of thunderstorm we use one more five-factored algorithm. This algorithm uses the Showalter index (SSI) and K index corrected by the windshear between the 500 and 850 hPa levels, temperature of 850 hPa level and the orographical height.

The position of fronts are determined using $\nabla^2\Theta_{ps}$ and the changing of wind direction on 850 hPa level.

Using the above mentioned algorithms we make the low level significant weather charts three times a day (06, 12, 18 UTC) using CorelDraw 5.0 and WinWord 6.0 programs (Figure 1.).

At present time a control system is being developed, which enables us to make corrected or amended chart, if needed.

We plan in the future to publish these charts on the international satellite telecommunication system called SADIS.

References

Mary M. Cairns, Ronald J. Miller : An Evaluation of Aviation Impact Variables (AIVs) Derived from Numerical Models, NOAA FSL Boulder, Colorado September 1992

F. Sándor V., Katkó B., Kerekes A., Rujàk L., Szalma J.: Development of Recognizing Method of Fronts Causing Hazardous Weather (in Hungarian), OMSz No. 48, Budapest, 1983

Fövényi A. : Tipization and Parametric Examination of Atmospheric Formations Causing Huge Precipitation on the Catchment Areas of River Danube and Tisza (in Hungarian), Diploma work, ELTE, Budapest, 1989

Götz G., Szalay G., Tänczer T. : Connection Between the Instability and Humidity Indices and the Convective Activity, (in Hungarian) OMSz XXXV., Budapest, 1968

HMSO : Handbook of Aviation Meteorology (3rd Edition),pp. 77-83, pp. 94-98, pp. 123-138, pp. 150-151, HMSO, London, 1994

ICAO : Annex 3, 11th edition, ICAO, Montreal, 1992

Spalding, T. R. : Significant Weather Charts, Forecasting for Airfields

Hall, B. A. : Use of NWP Data for Aviation Forecasting

Lunnon, R. W. : Aircraft Icing Problems — Liquid Water Content

Dalton, F. : Providing Advice on Weather Hazards for Aviation

Proc. " The Second Joint UK Met Office/WMO Aeronautical Forecasting Seminar " Reading 11-15 July 1994

Young, K. C. : Microphysical Processes in Clouds, pp. 23-107, Oxford University Press, New York, 1993

Visibility range analysis and forecast using data of automatic SYNOP and radar stations and NWP models

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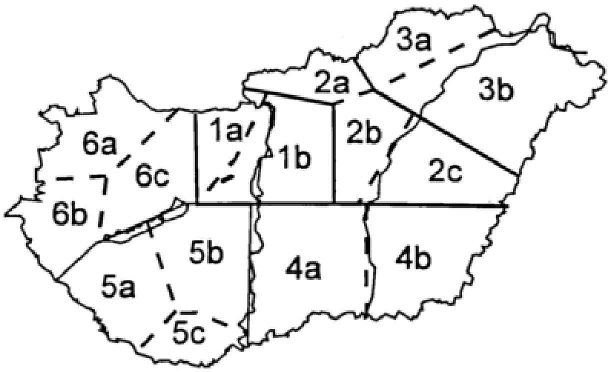
ABSTRACT

In the last five years the number of VFR (Visual Flight Rules) flights increased, while the number of visual meteorological observations decreased (from 31 to 25 at daytime, from 30 to 16 at night) in Hungary. So we had to make a method for the compensation of the missing visibility range data, and an other method for the correction of our visibility range forecasts.

In the Aviation Meteorological Centre of the Hungarian Meteorological Service (HMS AMC) we make forecasts for VFR flights for 15 Hungarian regions (Figure 1.).

Figure 1. VFR regions in Hungary



We have no visual observations from two regions in daytime hours and from five regions at night. We try to replace these missing visibility range data using data of automatic SYNOP and radar stations. These data are: wind direction, windspeed, temperature, dew point and precipitation intensity (mm/h). In addition to these data we took the parts of day (daylight, twilight, night) into consideration too. For making the visibility range analyses we used SYNOP statistics of a 21 years span (1975-1995) and a precipitation intensity data base of 3 years (1993-1995). We determined the visibility range using the relative humidity, the state and intensity of precipitation, 9 wind direction categories (calm, N, NE, E, SE, S, SW, W, NW) and 6 windspeed intervals (0, 1-2, 3-4, 5-7, 8-10 and greater than 10 m/s). At present time the program calculates the minimum available visibility range by using the measured humidity and wind data. When precipitation is observed by the radar or the automatic SYNOP station the program calculates the visibility in rain and in snow too. A new method is being developed for determining the state (frozen or liquid) of precipitation using radar data.

For the forecasting of visibility range we use the above mentioned surface data and categories, and more data, like windshear between the surface and the 925 hPa level (10 intervals), the base, amount and thickness of clouds (only in the case when the amount of clouds is greater than 4 octas), the dry lifting energy between the surface and the surface+700 m level (10 intervals), and a self-developed temperature forecasting method. The state of precipitation (liquid, frozen) is determined from the position, thickness and average temperature of the positive and negative temperature layers. This set of data is calculated from pseudo-temp (predicted profiles of temperature, humidity and wind) and precipitation data of the ALADIN (Aire Limitee Adaptation Dynamique Developpement International) mesoscale NWP model. At present time we have some problems fitting our temperature forecast to ALADIN data. The source of this problem is the difference between our predicted temperature and that of ALADIN, so in some cases the predicted dew point by ALADIN is higher than the predicted temperature by us. For the developing of these methods we used SYNOP and radiosonde statistics of a 21 years span, and a precipitation intensity data base of 3 years. The methods are being tested, but the forecasting part of the system is still under developing.

In the future we plan to build these methods into the operational practice, like making terminal aerodrome forecasts for airport Ferihegy, making visibility range forecast for the 15 VFR regions and making low level significant weather charts.

References

R. Brown: Observations of the structure of a deep fog, Meteorological Magazine 116, pp. 329-338, 1987

J. Findlater: Field investigation of radiation fog formation at outstations, Meteorological Magazine 114, pp. 187-201, 1985

Daniel Guedalia and Thierry Bergot: Numerical Forecasting of Radiation Fog. Part II: A Comparison of Model Simulation with Several Observed Fog Events, Monthly Weather Review 122, pp. 1231-1246, 1994

Gyarmati Gy.: Comparison of radar estimated rainfall with raingauge dat in Hungary, Proc. Seventeenth International Conference on Carpathian Meteorology, Visegrád 14-18 October, 1996

Nagy J.: The Estimation of Rainfall and Structure of Echoes Based on Digital Radar Measurements in Eastern Part of Central-Europe, Proc. Seventeenth International Conference on Carpathian Meteorology, Visegrád 14-18 October, 1996

Z. Petkovšek: Turbulent Dissipation of Cold Air Lake in a Basin, Meteorology and Atmospheric Physics 47, pp. 237-245, Springer-Verlag, 1992

WIT - WEATHER INFORMATION TERMINAL

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ABSTRACT

Since few years a aviation family has saw about an automatic providing of meteorological information for members of flight crew, operators and other users into aviation community. Generally for such system of providing information is used a term **self-briefing**. A rapidly development of technical facility allows also by the smaller country like Slovakia to supply with this kind of providing of meteorological information.

The first step to built our own self-briefing system (**W**eather **I**nformation **T**erminal - **WIT**) was an involving the modern telecommunication network connecting all our met-offices with the National Telecommunication Centre (NTC) to regularly operation in the 1993. At the same time the new PC-based terminals were developed and gradually installed on the all aerodromes. These new facility have allowed for our met-service to distribute the necessary products (alphanumerical and pictorial) for briefing of crew's members, operators or end users on the arbitrary aerodrome.

The philosophy of WIT is based on a need to distribute to the end users:

- alphanumerical information (e.g. METAR/SPECI, TAF, SIGMET, GAMET, AIRMET, forecasts and etc.)
- charts (significant weather charts, upper wind and temperature charts etc.)
- pictures (satellite and weather radar information)

and on a demand of the simple user-easy and user-friendly interface for preparing a pre-flight documentation.

To meet these demands the most used information depending on the flight plans on the selected aerodromes are transmitted direct to the aerodromes by NTC. Other information that are not regularly asked are possible to acquire on the request of user from NTC.

A hardware basis of WIT is a current PC (at least 486 processor and 8MB RAM) and an operating system QNX. The OS QNX allows to run of independent processes (multitasking). By a serial port and a modem line is the computer connected to the NTC. This connection can be made direct to the NTC or via a computer on the met-station (Integrated Meteorological System - IMS) which allows to gain information from the automatic aerodrome observing system (ASOS) or separated meteorological measure systems. Also it is possible to connect an AFTN line to obtain additional information such as e.g. SNOWTAMs. The laser or other printer is connected to the PC to print information.

The WIT operation is very easy. All functions are executed by mouse or keyboard. The bottom parts of all screens contain the actual help information to navigate the users. The WIT allows for users to obtain:

- The actual local weather information on the aerodrome as take-off information (wind speed and direction, temperature and dew point temperature, pressure, height of cloud base, etc.).
- The last local aerodrome meteorological report in a coded form (METAR/SPECI) and in a plain abbreviated language (MET REPORT/SPECIAL).
- The weather information on the selected aerodromes such as METAR, TAF, LONG-TAF, SIGMET, SYNOP etc. The user can choose one from several areas (around the Europe) and to obtain the last weather information on the aerodromes that are contained into OPMET MET 2A table. The information is displayed on the screen or it can be printed.
- The significant weather charts and upper wind and temperature charts. These charts are automatically sent to the WIT by NTC two time per day. The number of charts for transmitting is defined by the NTC operator. The user can print the chosen charts (the charts are not displayed on the screen).
- The WIT allows the user also to obtain information that are not regularly transmitted to the aerodrome by NTC. A separated function allows that the user would defined itself the necessary aerodromes and the WIT shall compile a request and send it to the NTC. The information is printed in the tabular from (model A2 of Annex 3).
- The forecasts for standard flight routes. The forecasts are prepared for regularly flights for selected aerodromes by the Central Forecasting Office of our MET Service. The user can print the forecast in the tabular form (model TA2 of Annex 3).
- The satellite (IR channel) and weather radar pictures (movie) to help the user obtain next detail information.

DROUGHTS RECORDED IN POLAND IN YEARS 1891-1990 AND ATTEMPTS AT THEIR PREDICTION

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ABSTRACT

Continuous monitoring and assessment of the course of meteorological and hydrological phenomena which occur in our country is one of the areas of interest of the Institute of Meteorology and Water Management (IMWM). On the basis of long-term observations, it was found that the decade covering the period from 1982-1991 was one of the driest ones. This finding has led us to undertake some studies the aim of which was to try and characterize droughts which occurred in Poland in years 1891-1990 using a more methodologically consistent approach. It was assumed that this would, in turn, allow to obtain information which would improve present possibilities of drought prognostication.

When describing drought phenomena in the above mentioned investigations, the following mutually interrelated groups of elements of the natural environment were taken into consideration: atmospheric conditions, surface waters and undegroud waters. In all, for the period from 1891-1990, data for 131 meteorological stations, 50 water-gauging profiles and 73 measurement stations of undeground waters (period 1951-1990) were tabulated.

In the period from 1891-1990 atmospheric droughts of varying intensity, range and duration occurred in the following years (in more than half of the analysed measuring points, annual totals of atmospheric precipitation were less than 90% of the norm): 1892, 1895, 1904, 1909, 1911, 1921, 1928, 1929, 1933, 1942, 1943, 1947, 1949, 1951, 1953, 1954, 1959, 1963, 1964, 1969, 1973, 1976, 1979, 1982, 1983 and 1989. From the above mentioned years, droughts in the following ones covered the largest areas: in 1969 (in 95% of analysed points), 1921 (in 92% points) and in 1904 (in 90% points). The deepest droughts in the analysed period were recorded in 1921 (in 56% points total annual atmospheric precipitation did not reach 75% of the norm), 1959 (52%), 1982 (42%), 1969 (40%) as well as in 1904 and 1942 (in 39% points).

The onset of atmospheric droughts occurred most frequently in the spring-summer period (in approximately 70% cases). The course of atmospheric conditions during this period had a decisive influence on the intensity and territorial range of this phenomenon. Drought spells usually ended during the autumn-winter period (November-February). During the analysed period of 100 years droughts occurred most frequently in March and in the period from June to September; they were rare in the period from November to February.

While analysing hydrological materials, a strong dependence of the occurrence of summer-autumn low-flow periods on atmospheric drought was observed. In most cases a low flow period began after 2-3 months during which the deficit of atmospheric precipitation was substantial. The response of the flow to the occurrence of precipitation was usually fairly rapid, i.e. in most cases the end of hydrological drought occurred either in the same or next month in which the sum of atmospheric precipitation was similar higher than the norm. In the case of winter low-flow periods, their onset was connected with the appearance of ice on rivers or with longer periods of low air temperatures (below 0°C) during which the surface runoff was arrested and ground water inflow to the river-bed was severely restricted.

On the other hand, the beginning of drought spell periods comprising the sphere of the first horizon of ground waters occurred most frequently in summer and autumn. These droughts exhibited their maximal territorial coverage in the winter-spring period and disappeared in spring or summer. This indicates that a hydrological drought in this area of geographical environment can be brought to an end only after ground water resources have been replenished during the winter-spring period.

Generally speaking, it was found that droughts occurred most frequently in the belt of lowlands in the central part of Poland. When analysing the drought phenomenon, particular attention was drawn to its duration in Polish conditions. The existing natural conditions cause that droughts in Poland exhibit greatest stability wish regards to underground waters and tend to show significant time and spatial mobility with regards to atmospheric conditions and surface waters.

The outlined time-spatial distribution of the occurrence of drought spell periods in Poland is economically unfavourable, especially from the point of view of agriculture, since major part of agricultural potentials of our country happens to be situated in regions where probability of occurrence of this phenomenon is quite considerable.

Careful analysis of the occurrence of droughts in years 1891-1990 allowed to draw valuable conclusions as to the origin and development of the phenomenon itself. It was also possible to recognize systems of meteorological factors affecting the development of atmospheric droughts, their frequency and duration. Furthermore, on the basis of droughts which occurred in the period from 1891-1990, mutual correlations between meteorological and hydrological processes were analysed.

Most frequently, the appearance of an atmospheric drought is associated with persistent maintenance of a stationary East-European high which, via Central Europe, joins with the Azores anticyclone. In such situations, at the accompanying lack of atmospheric precipitation in several days' periods or insufficient totals of atmospheric precipitation in the period of one month (below 50%) as well as in the period of several months (below 75% of multi-year average), a drought begins to develop gradually including successive elements of the geographic environment. The development and intensity of the atmospheric drought depends, to a considerable extent, on meteorological conditions which precede it (e.g. total seasonal atmospheric precipitation in the autumn-winter period, depth and duration of snow cover, air temperature and evaporation). Systematic and consistent observations of there meteorological conditions allow to monitor and issue warnings of a possible soil drought which can be followed by a hydrological one.

Since 1992 the IMWM has carried out continuous monitoring of drought prognostication. Every month a bulletin about current water resources of Poland is published in which detailed analysis of the meteorological-hydrological situation is carried out. In the situation when there is a threat of a hydrological drought, the bulletin is published every ten days. Simultaneously, in regional branches of IMWM, special services begin to operate whose responsibility is to monitor closely the development of the atmospheric and hydrological situation.

Finally, it is essential to emphasize that in the coming three decades atmospheric and hydrological droughts are likely to occur more often. This opinion is frequently found in numerous climatological publications which stress trends leading to global climate changes and prognosticate accompanying changes in total atmospheric precipitation and mean air temperatures. These predictions emphasize in particular a drop in total atmospheric precipitation in spring-summer periods, i.e. in periods when droughts occur most frequently.

However, at the existing level of scientific development, it is still impossible to predict the exact date of the onset of a drought. It is only possible to monitor its course and development and prognosticate its effect on economy, especially for agriculture. It is generally believed that continuous monitoring and careful analysis of the meteorological situation supported by data concerning current state of soil humidity can indicate if the initiated rainless period should be treated as the first stage of a drought or rather - taking into consideration the time of year, soil humidity and system of meteorological factors - a drought does not constitute a real threat.

METEOROLOGICAL CONDITIONING OF CONCENTRATION OR DISPERSION OF AIR CONTAMINATION IN POZNAŃ CONDITIONS /western Poland/

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ABSTRACT

The aim of this research project was to determine time occurrence of meteorological phenomena enhancing development of large concentrations of atmospheric contaminations or facilitating their dispersion. Results of these investigations constitute the basis for the elaboration of a statistical prediction of complexes of meteorological phenomena influencing the process of dispersion of contaminants.

The following factors were accepted as the ones which exert primary influence on the degree of contamination: wind velocity and direction as the element of weather which characterizes movement of air; fog, air humidity and atmospheric precipitation as the element determining the content of water vapour in the atmosphere. The following parameters were subjected to analysis: probability value of the conditional occurrence of a given factor (fog, wind $v > 10$ m/s) or complex of factors (fog and wind of $v < 2$ m/s, light wind and high air humidity > 80%, wind of $v > 7$ m/s and atmospheric precipitation) in individual months of the year for a given type of circulation (according to classification by Lityński) determined on the basis of a series of measurements from years 1981-1990 from Poznań meteorological station.

Similar analysis was performed in 1980s for the city of Kraków within the framework of a monitoring program for this town.

FACTORS ENHANCING CONCENTRATION OF CONTAMINANTS

FOG

Fog persists over Poznań for 15.2% of the year. It appears primarily in late autumn and winter months with its maximum in XI. In summer, it occurs only sporadically. During high pressure, the highest probability of its occurrence is associated with S_a, SW_a and SE_a types of circulation (36, 26 and 23%, respectively). The lowest probability of its occurrence is in E_a type of circulation (9%).

In cyclone type of circulations, the highest probability of fog occurrence was found in SE_c and E_c types (55 and 21%), while the lowest - in NW_c type (3%).

In autumn-winter months fogs occur in definite types of circulations with the probability of >50%.

WINDS OF $V \leq 2\ ms^{-1}$ AND FOG

This type of weather system occurs over Poznań in 8% days in the year. It occurs most frequently in XI, X and from XII-III. Weak winds and fogs occur primarily in flows from S_a, SW_a, NW_a (more than 15%). The highest probability of occurrence of this system, in cyclonal circulation type, is observed at SE_c (18%).

In months with the most frequent occurrence of this weather system, in various types of circulation, the probability is greater than 30%.

WEAK WINDS AND HIGH AIR HUMIDITY (F > 80%)

This weather system occurs in 10.6% days in the year. It is most frequent in IX-XII. Secondary maximum is recorded in the period from I-III. On average, it tends to accompany the anti-cyclonal type of circulation twice as frequently as the cyclonal one. In high pressure conditions, it is connected with the flow of air from N and S. At low pressure, probability of its occurrence is the highest at W and NE air flow.

During autumn-winter months the probability of occurrence of this system exceeds 50% many times.

FACTORS FAVOURING DISPERSION OF CONTAMINATION

STRONG WINDS (WIND VELOCITY $V > 10\ ms^{-1}$)

Strong winds blow over Poznań in only 2.2% of days in the year - with their maximum in X and IV. Practically speaking, strong winds do not occur in summer (during the entire period under examination, they never occurred in August). They occur mainly in cyclonal types of circulation with flows from W_c (in X - 12%) and N_c, sporadically in the SE_c, S_c types.

Very rarely they occur in SE_a and NW_a circulations.

In the autumn-winter and summer periods winds with velocity $V > 10\ ms^{-1}$ occur with the probability of >20% in many types of circulations.

WINDS WITH VELOCITY > 7 ms^{-1} AND ATMOSPHERIC PRECIPITATION

Weather conditions: wind and atmospheric precipitation have their annual distribution similar to the distribution of the remaining elements. The system occurs over Poznań sporadically (3.6% in the year). It was recorded most frequently in the period from IX-III. In summer, it occurs extremely rarely.

It occurs primarily in the cyclonal type of circulation with flows from N and W (19%).

In September and February it was recorded with the probability of > 50% in the N_c type, in November - W_c type.

IN CONCLUSION

Conditions which are exceptionally unfavourable for the dispersion of pollutants over Poznań occur, on average, in about 10% of the year. The number of their occurrences exhibits clear diversification in individual months of the year. They are observed most frequently in November and then in October and December. They are much more common in anticyclone (high pressure - main types of circulation: S_a, SW_a, SE_a) than cyclone (low pressure) situations.

Conditions favourable for dispersion of pollution over Poznań occur most frequently in W_c, NW_c and N_c types of circulations.

APPLICATION OF METEOROLOGY FOR ASSESSMENT OF ATMOSPHERIC POLLUTION (as exemplified by an enterprise situated in western Poland)

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ABSTRACT

In the last twenty years the state of pollution of atmospheric air in Poland has reached a level which places our country among the most contaminated regions in Europe, although it must be said that since 1990 the total weight of emitted contaminants has been gradually decreasing. Protection of atmospheric air implemented by the system of norms in the form of highest acceptable values of concentrations makes enterprises responsible for the preparation of measurement records of the air condition.

Documentation concerning air protection is prepared on the basis of the Pasquille's model of contamination dispersion in the air /operative in Poland since 1981/.

The state of thermo-dynamic equilibrium affecting intensity of atmospheric diffusion is determined in this model by annual and seasonal number of hours with different types of atmospheric equilibrium calculated on the basis of standard data about wind velocity and direction, cloudiness and precipitation. The mechanical factor generating turbulence is represented here by wind velocity, while the thermal factor - by the time of day and intensity of solar radiation. Usually 6 states of equilibrium are distinguished resulting from the classification of the unstable equilibrium into: outstandingly unstable, unstable and slightly unstable, and of the stable equilibrium into outstandingly and slightly stable; 11 classes of wind velocity /every 1 ms^{-1}/ and 12 wind directions /every 30 /.

In Polish legislation concerning protection of atmospheric air, there are some modifications of states of equilibrium connected with their specific applications:

- for purposes of air protection irrespective of the type of emission source /most common - point emitter or set of emitters/ - for the calculation of 30 min and longer concentrations as well as dusts in the immediate neighbourhood of the emitter > 20 m - 36 weather situations and 12 directions in the wind-rose throughout the year, during the heating period /15.10-14.04/ and in summer /15. 04 - 14. 10/ - basic version,
- for determination of concentrations from landfills taking into account periods of occurrence of definite states of soil: 0. 1 or 3,
- for determination of the pollution background taking into account periods: without precipitation, with rainfall /precipitation intensity < 1 mm/day, > 1 mm/day, with snowfall / for the whole area of Poland 13 calculation regions characterized by a relative uniformity of topographic conditions occupying the area of 12000 - 38000 km^2 were determined/.

The states of equilibrium were worked out for the region of the entire country /for approximately 57 meteorological stations, of which 13 are in western Poland/. Calculations were performed for 8 times of observations per day for consecutive decades /with the last period being 1981 - 1990/ obtaining three-dimensional tables of classified cases with regards to wind direction and equilibrium class. In the 1 ms^{-1} velocity interval cases of $v = 0\ ms^{-1}$ are recorded.

Analysis of frequency of occurrence of individual classes of equilibrium in different wind velocity intervals does not reveal significant differences resulting from the localization of the station.

Studies carried out by J. Walczewski /IMGW - Kraków/ showed that the Pasquille's method has one flaw /irrespective of its successive modifications/ - it tends to underestimate the share of stable equilibrium in favour of neutral equilibrium which, ultimately, occupies a dominant position /Table 1/.

Table 1

Comparison of assessment of annual share of 3 classes of equilibrium /exemplified by Kraków, according to J. Walczewski/

Equilibrium	Pasquille's method %	Assessment according to weather type %	Sodar observations 1980 - 1993
stable	29.4	40.7	52.3
neutral	50.0	36.5	20.9
unstable	20.6	22.8	26.8

Below we present an example of application of standard equilibrium states for the assessment of the effect of a specific enterprise /METALPLAST Buk situated in western Poland - 35 km W of Pozna / on air condition. Statistics of wind and equilibrium classes were worked out on the basis of data from Poznań - Ławica station.

Subsequently, on the basis of technical parameters of source emissions, the extent of 30 min. and annual gaseous contamination of air in the grid of receptors was determined with special analysis performed for 4 forest complexes situated within the range of theoretical influence of the factory /4 - 8 km radius/. Contaminations with SO_2, CO_2 and NO_x as well as dust up to 10 μm were taken into consideration.

The performed analysis revealed that in none of the 4 forest complexes norms of contamination concentrations in air /Polish norms/ are exceeded as the result of emissions from the above mentioned enterprise. The highest concentrations were recorded in conditions of stable and very stable equilibrium at 1 m/s wind velocity and NE, E, SE and W direction. Such extremely unfavourable meteorological conditions occur during the year only sporadically /NE in 2.0, E in 2.5, SE in 4.8 and W in 4.1% days in the year/.

Results obtained using the objective method of calculations and taking into account technical parameters of the enterprise and meteorological conditions show minimal impact of the activity of this enterprise on the condition of stands in the examined 4 forest complexes.

HIERARCHY OF REGIONAL REQUIREMENTS OF SMALL SCALE RETENTION IN POLAND

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ABSTRACT

Development of civilization is one of the causes of a steady increase of water consumption for human, industrial and agricultural needs. Poland is considered as a country with poor water resources and one of few European countries threatened with water deficit (calculated *per capita,* water resources in Poland are over two times lower than in Hungary or France).

Against the above described background it seems crucial and urgent to undertake all possible steps which could increase availability of water resources in Poland. Regionally and locally, the problem of small-scale retention is of key importance. It must be said that works on this problem have been intensified in the last two years and are coordinated by government agencies. In 1996 the Poznań branch of the Institute of Meteorology and Water Management (IMGW) was commissioned to prepare a project entitled: "Hierarchy of regional requirements of small-scale retention in Poland".

The notion of retention and increase of water resources is usually associated with construction of various types of artificial storage reservoirs. When analyzing problems of small-scale retention in Poland, attempts were made to approach the problem from a wider perspective seeing a host

of issues associated with the need for suitable development of rural landscape but also civilization requirements and expectations resulting from the human impact on natural environment.

When trying to determine area requirements of small-scale retention in Poland, spacial variability of the following environmental elements were analyzed in the context of assessing water deficits in a given region:

- distribution of average annual totals of atmospheric precipitation,
- duration of atmospheric droughts,
- duration of hydrological droughts,
- climatic water balance - mean values in periods of occurrence of atmospheric droughts,
- distribution of average low runoff,
- marshlands and forests constituting areas of natural water retention,
- distribution of lake water resources,
- soil types,
- areas of special natural values,
- water deficits of some selected crops during vegetation period at an assumed yield and soil type.

Finally, on the basis of investigations and discussions, a five score regional hierarchy of needs for small-scale retention was adopted. The basis for the adopted hierarchy was the spatial distribution of the climatic water balance calculated for drought spell periods in years 1951-1990 as well as frequency of occurrence of the lowest states of the first horizon of underground waters as an indicator of natural retention. Both parameters were plotted onto maps. In the result of isolation of regions with common features, a map of regional hierarchy requirements for small-scale retention was developed (Fig. 1). Depending on planning and decision-making requirements, it is possible to shift from a five score hierarchy (5 categories) to a three score hierarchy (3 categories) by merging categories I and II and IV and V.

The above presented situation is unfavourable from the point of view of economical development, especially with regards to agricultural requirements. As it can easily be noticed, the worst deficit of water resources occurs in regions with long traditions of development of intensive agricultural production.

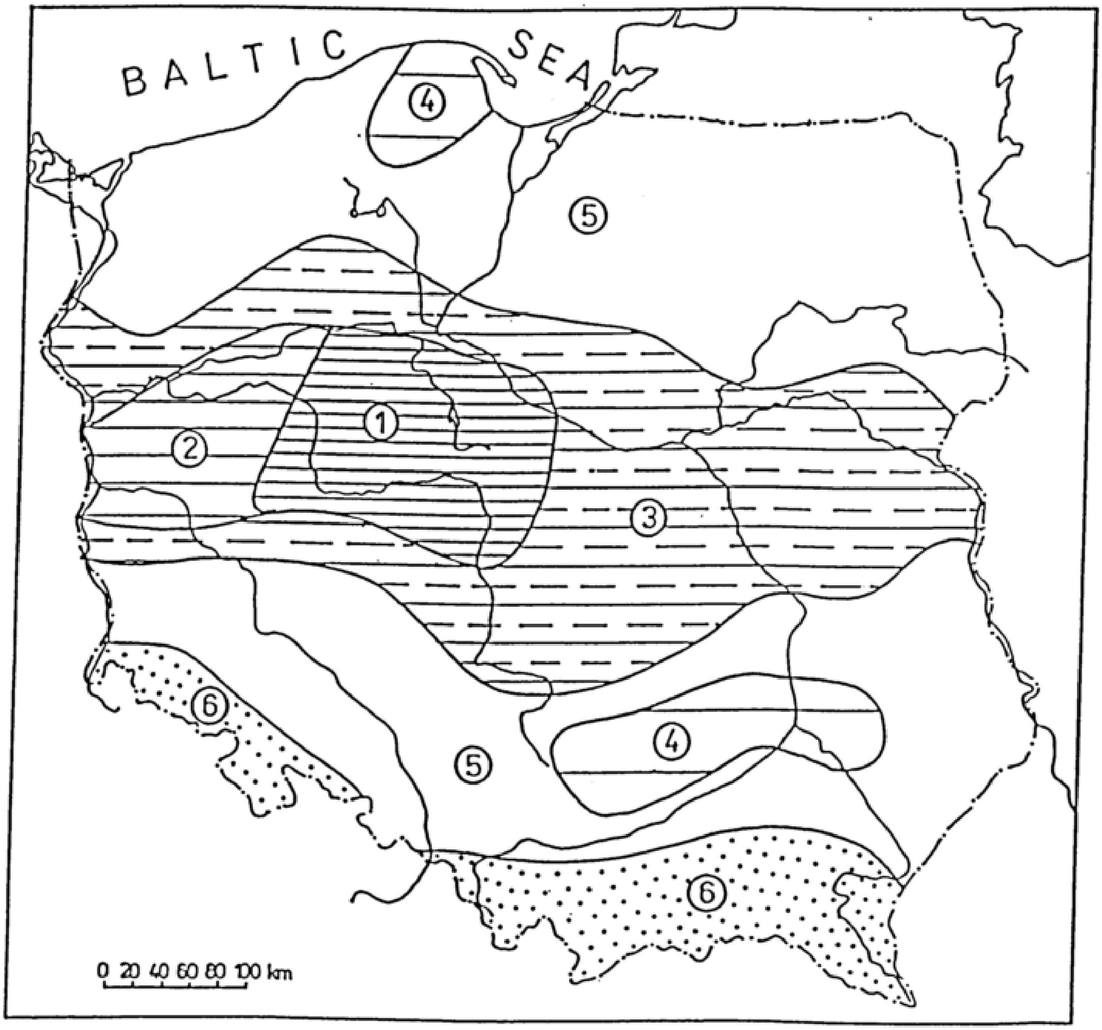

Fig. 1. Area hierarchy of small scale retention requirements:

1-5 - area category,

6 - regions not included in the analysis.

INTEGRATED METEOROLOGICAL SYSTEM

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ABSTRACT

Introduction:

Slovak Hydrometeorological Institute (SHMI) recognized the needs of variuos customers for timely and reliable delivery of processed meteorological data and information. It is the philosophy of SHMI to satisfy changing needs of users.Therefore one of the development projects was devoted to design so called Integrated Meteorological System (IMS) that would be able to serve both SHMI and its customers in their day to day activities. Joint Project with the private company MicroStep HDO Ltd. has started in October 1993 and was put into operation in October 1994. From the substance of the Project it is continuously and strong under development.

Description of IMS:

IMS was designed as an open system for various different tasks. Among them there are:

1. System for meteorological observer, allowing data collection from Automatic Station, data presentation, pre-processing, automatic data checking and encoding, temporal storage and dissemination to National Telecommunication Centre (NTC)
    - This module is used in the National Observing System as a standalone System or together with the automatic sounding station.
2. System for meteorological offices, allowing data retrieval from the NTC data base, data decoding, data post-processing and presentation.
    - This module is used in the SHMI´s Regional Offices and meteorological military Service.
3. System for aviation, allowing data retrieval from the NTC database, data decoding, data post-processing, presentation in a special way for pilots and air traffic controllers in both manual mode and as an automatic self-briefing terminal.
    - This system is used at the airports either in the Meteorological briefing or in the Air Traffic Control Service.

4. System for Tourism allowing data retrieval from the NTC database, data decoding, data post-processing, presentation in a special way for public understanding.
    - This system is used in tourist areas especially in the High and Low Tatras mountains, in hotels, mountain rescue service and avalanche warning service.
5. System for commercial and non-commercial users, allowing data retrieval from the NTC database, data decoding, data post-processing and presentation.
    - This system is used at users side like, commercial meteorological services, public warning and rescue authorisation service.

Software of IMS allows site configuration with system of privileges, self education and training all basic modules, remote updating and software maintaining.

IMS was designed as a low cost workstation based on PC technology. It works under operating system QNX 4.2.1 and QNX Windows 2.3.

IMS is an integral part of the SHMI´s communication network. This network spreads over the whole territory of Slovakia and users can connect its IMS to the nearest hub of SHMIś private data network. Special emphasis was put in communication aspects thus allowing timely dissemination of any kind of meteorological messages and information including internal email communication.

Conclusion:

IMS took a bigger part of the work of observers resulting in the reducing of the overall number of observers and the same time raising the quality and quantity of the meteorological messages from observing network.
IMS speeds up the communication between regional offices and central databases and among offices themselves. IMS allows them to retrieve any data with the sufficient level of presentation.
IMS helps many users to get meteorological data and information in a modern electronic way necessary for their further processing, presentation and decision making.

Integrated Meteorological System

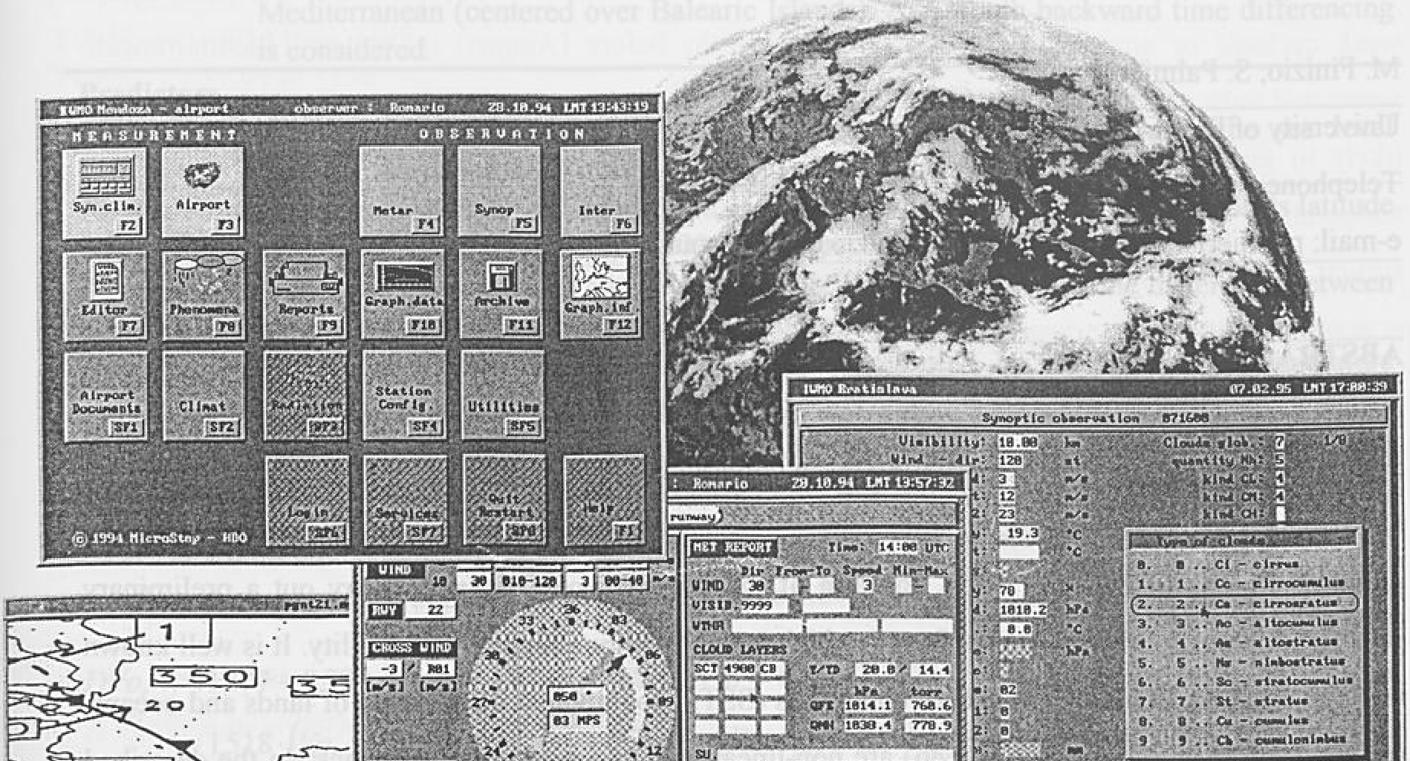

Figure: Examples of some screen pages of the IMS

A PRELIMINARY APPROACH TO SEASONAL FORECASTING IN WESTERN MEDITERRANEAN BY MEANS OF A NON-LINEAR STATISTICAL TECHNIQUE

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ABSTRACT

Reliable meteorological outlooks with a few months lead, in spite of their unavoidable limitation to the provision of information representing mean conditions over rather large areas, are likely to have a huge impact on human activities, with special reference to agriculture. Following a line originally proposed by Palmieri et al. (1995), the aim of the present work is that to carry out a preliminary investigation on the role of various factors which may affect long range predictability. It is well known that the interaction between boundary conditions (SST, geographical distribution of lands and oceans, surface hydrological cycle and albedo) are non-linear, due to a number of feedback. In the described framework, with the intent of investigating about an alternative approach in which model structure is derived by observables, an advanced statistical methodology able to capture non-linear effects, namely a recent version of the Multivariate Adaptive Regression Splines (MARS), initially introduced by Friedman in 1991, is applied. The research goal is that of detecting possible teleconnections between some significant thermal patterns and relative vorticity at a given site. Starting from a number of observables in the form of time series of meteorological elements, a model capable of fitting past records and predicting monthly vorticity time changes in Western Mediterranean is implemented. For this purpose a data set of Northern Hemisphere monthly meteorological data (octagonal grid), provided by the USA National Meteorological Center (NMC - now NCEP), is used. The data set covers the period January 1946 - June 1989. The total number of monthly values of both predictand and predictors (Table 1) is 518 (about 44 years). The first 470 are used to create and calibrate the model, while the last 48, about 10% of the whole set, are used as an independent sample for a preliminary test of the predicting skill of the model.

The model development (Eq. 1) is preceded by a preliminary phase with the intent to search for correlations and to find existing cycles within time series being analysed. On the basis of these information, some indications about potential predictors and their interactions are derived.

Predictand	
Dvo_t	$= Vo_t - Vo_{t-2}$: the time change of relative geostrophic vorticity at 500 hPa (*Vo*) over West-Mediterranean (centered over Balearic Islands). A 2-month backward time differencing is considered.
Predictors	
Nao	North-Atlantic Oscillation (NAO), defined as the difference between the sea level pressure (*slp*) anomalies over Azores and over Iceland;
Tg, Azz	Azores semi-permanent anticyclone described by the trigonometric tangent of its latitude and the geostrophic vorticity at 500 hPa, respectively;
Paco	North-Pacific ENSO (El Niño-Southern Oscillation), defined as the difference between *slp* anomalies at Western coast of Mexico and Manila;
Tmp, Tma	meridional thermal horizontal gradients, represented by the 850 hPa temperature difference between high (60°N) and low (30°N) latitude over Pacific (longitude 170°W) and North-Atlantic area (longitude 80°W), respectively;
Flp, Fla	zonal flow intensities (same latitudes and longitudes as thermal meridional gradients).

Table 1 Atmospheric parameters and factors considered. Each time series is standardised and a three-month running average is applied (weight : 0.25, 0.50 e 0.25).

$$
\begin{aligned}
DVo_t = & -1.807 + 0.794\cdot\left(Vo_{t-4}+1.813\right)_+ - 0.125\cdot\left(Vo_{t-4}+1.813\right)_+\cdot\left(Tma_{t-12}+2.166\right)_+ + \\
& -1.518\cdot\left(Vo_{t-4}+1.813\right)_+\cdot\left(Tg_{t-2}+0.263\right)_+\cdot\left(Paco_{t-2}-0.540\right)_+ + \\
& +0.360\cdot\left(0.853-Vo_{t-3}\right)_+\cdot\left(Tma_{t-6}+2.166\right)_+ + 0.284\cdot\left(0.853-Vo_{t-3}\right)_+\cdot\left(Tma_{t-12}+0.941\right)_+ + \\
& +0.743\cdot\left(0.853-Vo_{t-3}\right)_+\cdot\left(-0.316-Tg_{t-3}\right)_+ + \\
& -0.375\cdot\left(Tmp_{t-12}+0.119\right)_+ + 0.921\cdot\left(Tmp_{t-12}+0.119\right)_+\cdot\left(Tma_{t-2}-0.735\right)_+
\end{aligned}
$$

Eq. 1 The proposed model. $(x - x_o)_+$ is a function assuming its actual value when the argument is positive and 0 otherwise.

The value obtained for the model selection criteria (SC) is -0.9711 while the standard error of residuals is 0.025. Model residuals' distribution is nearly normal. Distribution of results is somewhat narrower than that of observed data, indicating that the model tends to underestimate extreme events. In fact, the variance accounted for is ~64%, with a correlation in the sample of 0.80 with a mean square error of 0.279. This result is practically the same in the prediction test (0.78 with a MSE of 0.255), a symptom of model stability. On the basis of a comparison of results for both "main data sample" (MDS) and "independent data sample" (IDS), the presented model is selected as the best within the set of a number of schemes derived by means of MARS methodology. Alternative MARS models often show better results in the calibration phase, but their output deteriorates in the prediction test.

After a short review of the MARS methodology the various terms appearing in the model equation are discussed and some possible physical and dynamical interpretations proposed.

When a prediction of the vorticity time changes between September and November is computed a weak cyclonic or anticyclonic vorticity three months before (August) in Western Mediterranean, associated with a small horizontal temperature gradient in Atlantic area six months before (May) is likely to give rise to an appreciable increase of cyclonic vorticity. Moreover a large horizontal temperature gradient in Pacific area 12 months before hampers the decrease of vorticity. Applying similar considerations to April (the central month of a season in which a secondary rainfall maximum is present in the Mediterranean area) the Atlantic subtropical anticyclone somewhat northward of its normal position and an above normal value of the surface pressure difference between western coasts of Mexico and Manila (two months before) are elements hampering the increase of vorticity in Western Mediterranean. On the other hand a weak temperature gradient pole-equator in Pacific area, twelve months before, coupled with a below normal pole-equator temperature gradient in Atlantic, two months ago, would favour an April increase of vorticity.

The developed model is tested on a suitable independent data set with very encouraging results. The comparison between the non-linear scheme and a linear one, indicates, when MARS methodology is used, a gain in accounted variance of about 9%. Moreover MARS model seems to be more effective in catching up fast variations. An ensemble forecast exercise, carried out to check model stability in reference to the uncertainty of input quantities, is also supporting the stable performance of the model.

In conclusion, the use of MARS technique, appears effective in describing the non-linear dynamics of time series and, at the same time, in predicting, with a two month lead, the evolution of relative geostrophic vorticity over Western-Mediterranean area. Interesting connections between atmospheric phenomena far apart in time and space, which could be hardly detected by other means, are also singled out, providing a base for further studies and a better understanding of atmospheric general circulation.

REFERENCES

Friedman, J.H., "Multivariate Adaptive Regression Splines", *Annals of Statistics*, **19**, 1, 1-67, 1991

Palmieri S., et al., "Mediterranean Climatic Extremes (MECLEX)", Project Report, Proposal to European Commission - Directorate-General XII for Science, Research and Development - Research and Technical Development Programme in the field of ENVIRONMENT AND CLIMATE, 1995

MESOSCALE ANALYSIS AND CLOUD SEEDING: SOME CASE STUDIES

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ABSTRACT

Within the "Rain Plan" project (1988- 1994) jointly implemented by the Puglia (southeastern portion of Italian Peninsula) Regional Council and Tecnagro (a non-profit organisation devoted to the technological development in agriculture), systematic cloud seeding experiments have been carried out. The glaciogenic material used was silver iodide released from airplane at an average altitude of 3000 m along convened flight segments.

In order to allow an objective evaluation of results, a randomised seeding program has been implemented making alternative use of two areas (target or control). A bulk statistical analysis of results, limited to 24 hour precipitation totals and considering, in an indiscriminate way, all available cases, was not able to contribute to the scientific interpretation of the project results. Obviously the interpretation of experiment results cannot solely rely on a black-box statistics.

In a different approach, cases were classified according to precipitable water in the layer 700-500 hPa. In this case results show that a statistically significant increase in precipitation, due to seeding, actually occurred in the case category being considered (Silverman ,1996).

Conceptual developments in weather modification by cloud seeding have recently come about through the use of a new generation of cloud models and particle-growth models solved by numerical techniques (Orville, 1996).

Moreover meteorological analysis based on high resolution models allow detailed description of meteorological fields to support both project evaluation and understanding of seeding effects. In the case of Puglia it is necessary to take into account the effect on the atmosphere brought about by the highground bordering the western boundary of the region, as well as the thermodynamic impact of the Taranto Gulf, an effective source of sensible and latent heat . A diagnostic mesoscale model based on the mass conservation constraint (Douglas et al.), with a horizontal resolution of 5 km, is used to determine low level meteorological parameters. The scheme includes (a) the kinematic effects of terrain modulated by a function of the Brunt-Vaisala frequency and the mean wind speed, (b) the terrain blocking effects controlled by a local Froude number depending on wind speed, stability and obstacle height. The model allows to take into account the effect on the low level currents caused by the highground bordering the western boundary of Puglia, as well as any minor alteration of the flow due to sea-land changes.

The investigation, limited to some cases of particular interest, is carried out to point out some aspects to be considered in a future thorough evaluation study. Particular attention is dedicated to the space distribution of variables in reference to surface topography and sea-land effects, to stress non homogeneity between target and control areas of the experiment.

The study has shown that some kind of systematic non homogeneity between target and control areas may be expected due to the interaction of surface physical properties and the atmosphere:

- in southwesterly synoptic patterns, differences in the experiment areas may be determined by the fact that air streams may loose part of their moisture after crossing Southern Appennines;

- the Gulf of Taranto is a source of sensible and latent heat of dimension and form quite suitable to interact with small scale atmospheric disturbances. This may give rise, in many cases, to greater instability and moisture over southeastern Puglia.

As an example, the non homogeneity of target and control areas is shown in one specific case (14.02.97, 1300 UTC: Fig.1 presents the 850hPa wind field obtained by means of the mass conserving high resolution analysis model, showing a mesocyclone affecting the region under consideration; target area (B) experiences southeasterly winds, while control area (C) a northerly flow. The corresponding precipitable water field, shown in Fig.2, indicates an appreciable decrease of precipitable water when passing from target to control area. At the same time the two figures provide an example of the analyses being available at short time intervals (1-6 hours) for each "seeded" case being considered.

The preliminary investigation of some cases, indicates that in the project evaluation it is necessary to take into account the effect of various factors, such as the different impact of seeding in large or smaller clouds, the non homogeneities in three-dimensional fields of atmospheric parameters between target and verification areas, the possibility of seeding effects being exported outside the target area due to the wind drift and, last but not least, the necessity of correcting raingauge determinations for evaporation and wind induced losses.

It is concluded that both mesoscale meteorological analysis and considerations based on cloud simulation models are primary tools in the evaluation of cloud seeding projects.

References

Douglas, G.S., R.C. Kessler, and E.L. Cair, 1990: Diagnostic Wind Model. U.S. *Environmental Protection Agency, EPA-450/4-90-007C.*

Orville, H.D., 1996: A Review of Cloud Modeling in Weather Modification. *Bulletin AMS* , 77, N.7, 1535-1555.

Silverman, B., 1996: The Puglia Experiment: A data Classification Study. *Progetto Pioggia Puglia. CD-ROM Tecnagro.*

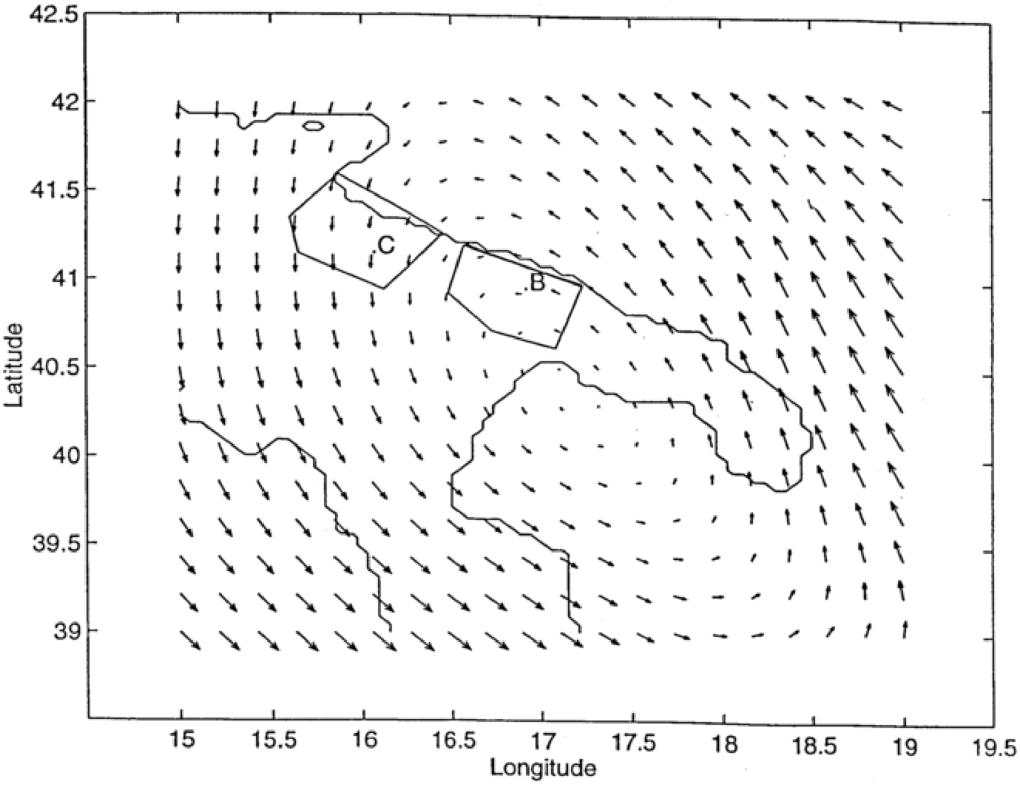

Fig.1 - 850 hPa wind field (⟶ = 10 m/s) - 14.02.94 - 13 UTC , obtained by means of a mass conserving high resolution model ($\Delta x = 5$ km) showing a mesocyclone in the Gulf of Taranto.

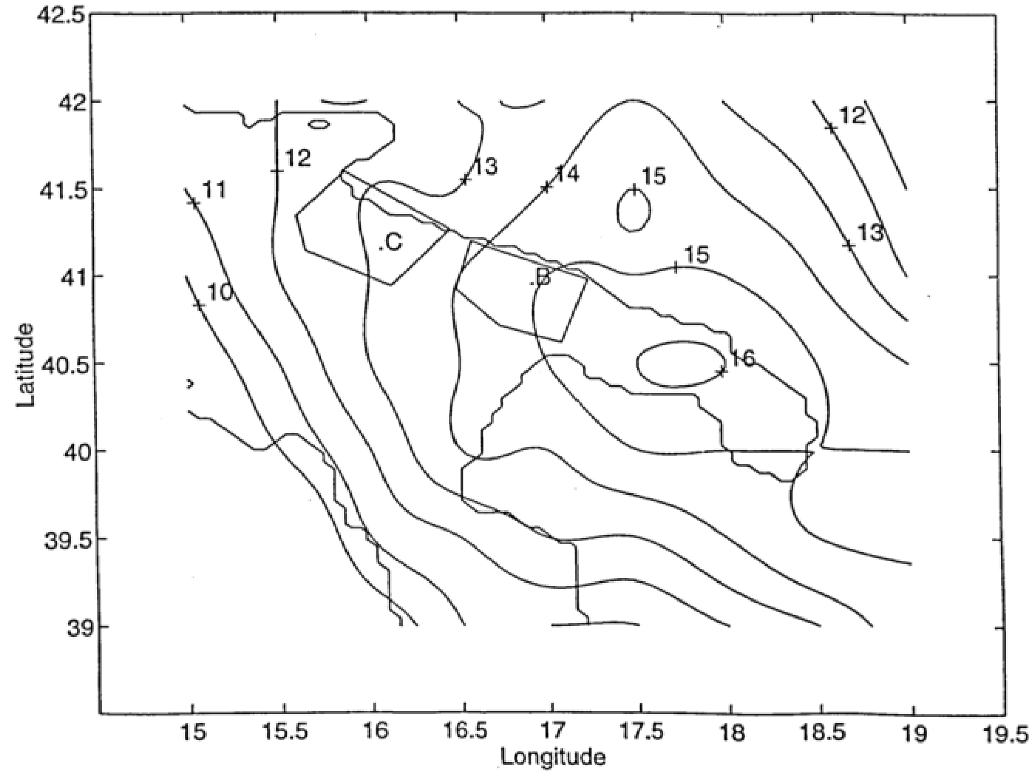

Fig.2 - Precipitable water (mm) - 14.02.94 - 12 UTC. The decrease of this quantity when passing from B to C areas may be noted.

MECHANISMS TO PROMOTE ENVIRONMENTAL SCIENCES TO PUBLIC

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ABSTRACT

During the past several years, there has been growing concern about the inadequacy of environmental science education and promotion in countries around the world. The crux of the problem seems to be that it is difficult to link the science-rich sectors of the societies (universities, colleges, research institutes, etc.) with the science-poor sectors (elementary and secondary schools, industry, etc.).

In an effort to attract people's attention, create public interest in atmospheric topics and environmental sciences, a series of "activities" was methodologically organised by the National Observatory of Athens, Greece within the *Open Doors* project co-ordinated by the Institute of Meteorology and Physics of the Atmospheric Environment (IMPAE), as well as within the project about organising the NOA's *Liaison Office*. Both projects are being funded by the General Secretariat of Research and Development of Greece. Their major objective is to make the scientific and research activities in the field of Meteorology and Environmental sciences familiar to the public as well as to the scientific and enterprise community.

To achieve this objective NOA uses both conventional and modern technology mechanisms. Conventional mechanisms consist of printed material of NOA's institutes' profiles and activities in addition to information of general interest (e.g. climatological mean values of the city of Athens, one professional video, which is intended to be played by the various channels of Greek television, small term seminars and guided tours with audio-visual exhibition. Participation of its researchers in conferences and meetings on weather and environmental sciences popular education is one of the best ways to promote the research activities of the observatory.

Concerning the modern technology mechanisms, Internet and World Wide Web (WWW) were used to create a user friendly learning environment. The specially designed WWW pages include not only information of general interest about the NOA but also about the environmental sciences. Links to special resources have been added to the WWW pages, which lead the user to pages about weather forecasting, satellite images, global resources and databases with material on various environmental topics. The WWW environment was used as it offers facilities like ease of use and access to informative material and, of course, interactivity. Furthermore, the research results as well as the research projects are being made public to the research community via the efforts of a special team of the *Liaison Office* dedicated to access relevant scientific databases and inform them.

Experience so far has shown that people in Greece are interested in learning about the environment. IMPAE succeeds in developing mechanisms that attract public attention (c.g. lots of school children and common people arrive at the NOA and they are satisfied by the guided tours) which enable people to learn more.

ON THE USE OF REGIONAL ATMOSPHERIC MODELS FOR THE STUDY OF SEVERE WEATHER PHENOMENA IN EUROPE

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1. INTRODUCTION

In the frame of this work, atmospheric simulations of different severe weather phenomena affecting Europe and mostly the Eastern Mediterranean area will be presented. These simulations were performed with the aid of the Colorado State University/Regional Atmospheric Modelling System (CSU/RAMS). The nesting capabilities of RAMS model as well as its explicit microphysics package permitted to have an insight on severe weather past events and explore their thermodynamic and dynamic structure. This presentation will be focused on the formation of a sub-synoptic vortex over central Mediterranean and a cold front event observed over the British Isles. Emphasis will be given in the presentation of the 3-D structure of the analysed systems in order to give an integrated view of their formation and life cycle. The analysis of these past events might be of interest for both researchers and forecasters.

2. MODEL DESCRIPTION

The Regional Atmospheric Modelling System (RAMS) is a merger of a nonhydrostatic cloud model (Tripoli and Cotton, 1982) and a hydrostatic mesoscale model (Mahrer and Pielke, 1977). A general description of the model and its capacities is given in Pielke et al (1992). There are several specific features of RAMS: two-way interactive nested grid structure, terrain following coordinate surfaces with cartesian or polar stereographic horizontal coordinates, cloud microphysics parameterization at various levels of complexity, modified Kuo cumulus parametrization, radiative transfer parameterizations (short and longwave) through clear and cloudy atmospheres, various options for upper and lateral boundary conditions and for finite operators, various levels of complexity for surface-layer parameterization (soil-layer moisture and temperature model, vegetation parameterization etc.).

The ECMWF 1° gridded analysis files were used to initialise the model. The ECMWF data are objectively analysed by the RAMS model on isentropic surfaces from which they are interpolated to the RAMS grids. These fields were used in order to nudge the lateral boundary region of the coarser grid every six hours. The ECMWF fields of the sea-surface temperature and topography derived from a 30 sec terrain data retrieved by NCAR have been used for both applications.

3. VIEW OF A MEDITERRANEAN TROPICAL-LIKE STORM

On 14 to 16 January 1995 a convective perturbation with features similar to a mature tropical storm was depicted from satellite imagery over the region of southeastern Mediterranean (between Italy and Greece). This "tropical storm" had a clearly defined eye as well as spirally distributed cloudbands developed around the eye. In order to study the dynamical characteristics of this event, model simulations have been performed using the nonhydrostatic mode of CSU-RAMS, explicit microphysics and grid nesting. More precisely two nested grids have been defined: the outer with 45 km horizontal grid interval and the inner with 15 km horizontal grid interval. The model results were analysed in order to identify the model capabilities and limitations for simulating the mesoscale structure of this event.

The model succeeded in reproducing the circulation associated with this cyclone. The predicted location of the vortex is consistent with the satellite images (not shown). An interesting overview of the vortex is presented in

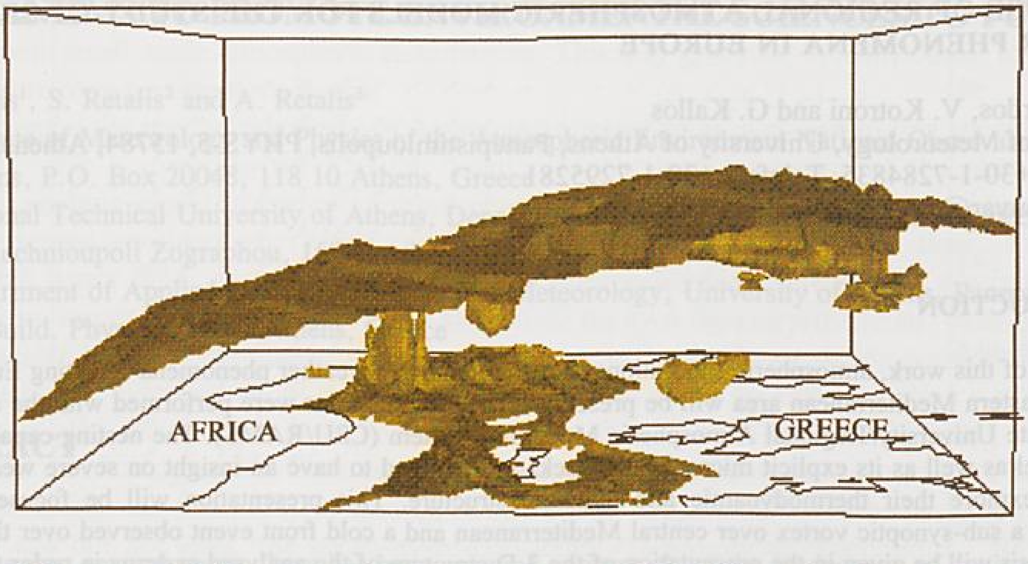

Figure 1: 3-D structure of the vortex at 1200 UTC 16 January 1995. Oblique view from the east of the 304 K equivalent potential temperature isosurface inside the second grid of RAMS.

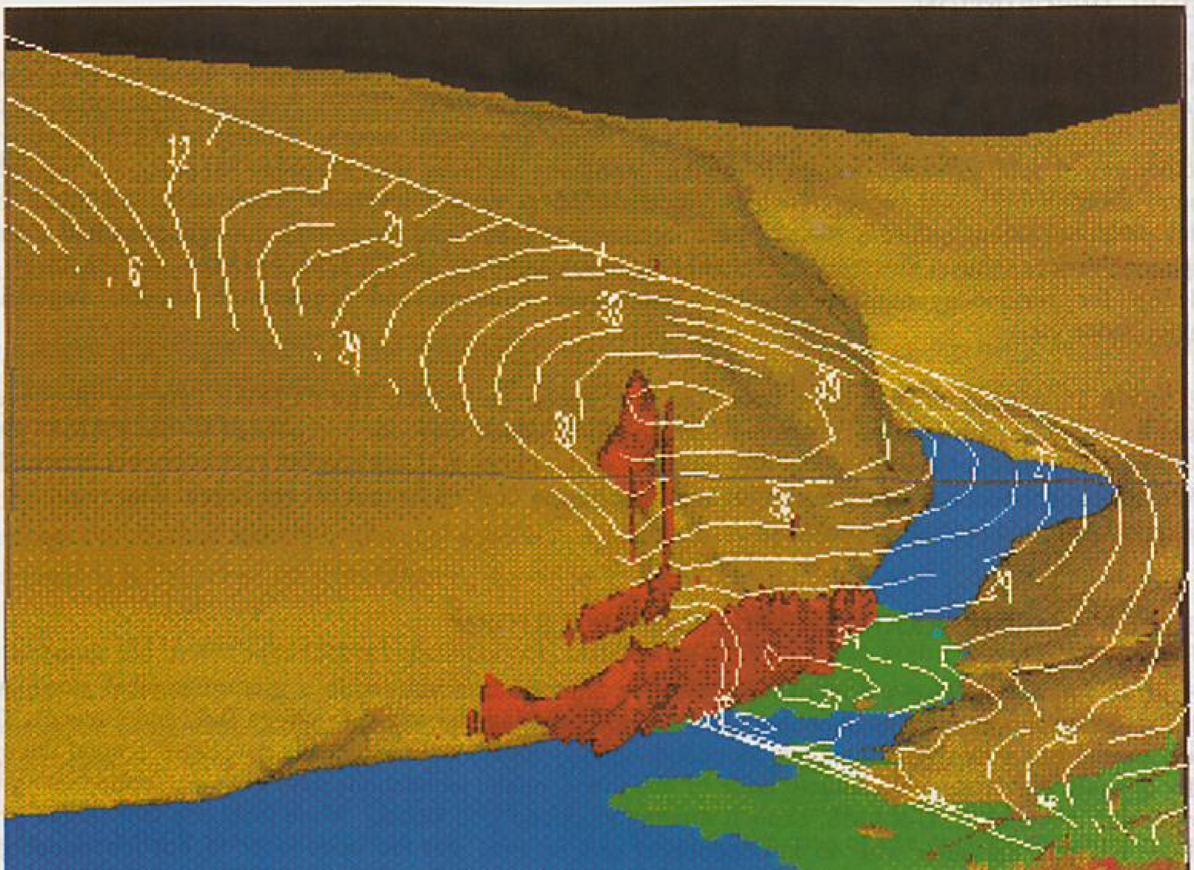

Figure 2: 3-D structure of the cold front at 2200 UTC, 11 November 1987, within the intermediate grid of RAMS. The 304 K thetae isosurface is represented with brown, the 20 cm/s vertical velocity isosurface is represented with red while the along front wind component is given at a cross section perpendicular to the front, contoured at 3 m/s interval.

Figure 1, where the 3-D structure of the equivalent potential temperature is shown at 1200 UTC 16 January 1996. At this time the 304 K θ_e isosurface has formed a structure like a vertical conduit from the mid tropospheric layers within the vortex centre. This 3-D structure of θ_e shows also a good agreement with the 3-D structure of a simulated tropical cyclone presented by Tripoli (1992).

4. SIMULATION OF AN EXTRATROPICAL CYCLONE

Another example of RAMS application on the study of mesoscale phenomena is the simulation of a cold front which reached the area of Brittany, France on 11 November 1987. This front is known as the IOP2 case-study of FRONTS87 and it has been the object of several investigations in the past, due to the interesting characteristics of the observed front. The front was characterised by multiple low-level jets (Kotroni and Lagouvardos, 1993) and a strong line convection (Chong et al, 1991). The interaction of the upper and low-level jet has been investigated with the aid of a hydrostatic model (Sortais et al, 1993), while the dynamics of the rainbands and the line convection have been studied with the aid of a 2-D non-hydrostatic cloud model (Redelsperger and Lafore, 1994).

The aim of this study was to describe through a 3-D non-hydrostatic research model, the circulations associated with the upper and low-level jets as well as the narrow cold front rainband (NCFR) of the IOP2 cold front. Figure 2 presents a synthetic picture based on the fields predicted by RAMS intermediate grid (horizontal grid increment of 20 km). This figure gives a 3-D view of the system with the frontal discontinuity delimited by the 304K isentrope, and the updrafts just ahead of the front and in the cold side of the low level jet.

5. REMARKS

The use of a non-hydrostatic research model consists an important tool in analysing severe weather phenomena. Model results presented using the University of Wisconsin VIS-5D graphics capabilities help to improve our insight on the 3-D structure of such systems. Based on such type of analysis of severe weather past events, conceptual models can be derived for the features and the life cycle of these systems. In the frame of the poster presentation some more applications of RAMS on the study of severe weather events over the Mediterranean will be discussed.

REFERENCES

Chong, M., G. Jaubert and M. Nuret, 1991: Small mesoscale structure of a cold frontal rainband. Pp 181-184 in *Preprints 25th International Conference on Radar Meteorology*, AMS.

Kotroni V. and Lagouvardos K., 1993: Low-level jet streams associated with atmospheric cold fronts - seven case studies from the FRONTS87 experiment. *Geophys. Research Letters*, **20**, 1371-1374.

Mahrer, Y. and R.A. Pielke, 1977: A numerical study of the airflow over irregular terrain. *Beit. zur Phys. der Atm.*, Vol. 50, pp. 98-113.

Pielke, R.A, W.R. Cotton, R.L Walko, C.J. Tremback, W.A Lyons, L.D. Grasso, M.E. Nicholls, M.D. Moran, D.A. Wesley, T.J. Lee, and J.H. Copeland, 1992: A comprehensive meteorological modeling system - RAMS. *Meteorol. Atmos. Phys.*, 49, 69-91.

Redelsperger, J.L and J.P Lafore, 1994: Non-hydrostatic simulations of a cold front observed during the FRONTS 87 experiment. *Q. J. R. Meteorol. Soc.*, 120, 519-556.

Sortais, J-L, J-P Cammas, X.D. Yu, E. Richard, R. Rosst, 1993: A case study of coupling between low- and upper-level jet-front systems: Investigation of dynamical and diabatic processes. Mon. Wea. Rev., 121, 2239-2253.

Tripoli G. J. and W. R. Cotton, 1982: The Colorado State University three-dimensional cloud/mesoscale model-1982. Part I. General theoretical framework and sensitivity experiment. J. Rech. Atmos., 16, 185-220.

Tripoli G.J, 1992: An explicit three-dimensional non-hydrostatic numerical simulation of a tropical cyclone. *Meteorol. Atmos. Phys.*, **49**, 229-253.

MESAN - Mesoscale Analysis

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ABSTRACT

MESAN is a system for analysing surface parameters and clouds. The following parameters are being analysed:

- 2-meter temperature
- precipitation in mm water for 1,3,12 and 24 hours accumulation time, and for new snow-cover in mm.
- wind speed
- visibility
- relative humidity
- total cloud cover
- amount of low clouds
- significant cloud cover
- probability of observing cloud cover
- hight of cloud base
- hight of cloud top
- depth of snow cover
- sea surface temperature

Hirlam data are normally used as first guess field. Observations are taken from synop, metar, Swedish climate stations, satellites, radars and automatic stations.

Method

The analysis method is optimal interpolation with structure functions optionally taking into account surface characteristics like fraction of land/water and altitude.

Precipitation

Precipitation analysis is performed using a variable first guess error making it possible to increase spatial resolution in data spars areas. The description of the error varies as function of prevailing weather situation. It is based on a statistically established relation between wind, orography and variations in friction and latitude. With that relation approximately 50 percent of the observed climatological varians can be explained. Tests, via a runoff model, shows an inhanced capability for the analysis to describe variations in precipitation.

Before entering the analysis radar data are subject of efforts in minimizing systematic errors. Anomalies echos has shown not to give reasonable wind estimates from doppler data, thereby making it possible distinguish between false and real precipitation. In weather situations with anomalous echos, non doppler radars are checked using a consistency control with overlapping area of other radars. Bright bands are considered present, when high reflectivity and temperature around zero centigrade from Hirlam vertical temperature profile, are observed. The highest values are reduced using statistical knowledge of vertical reflectivity profiles of bright bands.

Temperature

When analysing the 2-meter temperature, the structure functions are modified, not only depending on horizontal and vertical distance but also on difference in altitude. This makes it possible to describe local variations in mountainous and coastal areas.

Visibility

The first guess for visibility analysis is generated from analysed values of relative humidity, precipitation and snow. Variations in relative humidity can alone explain 80 percent of variations in visibility, and combined with precipitation nearly 90 percent. By genererating the first guess from other parameters, consistency between the different analyses are achieved, and Hirlam data can be utilized

Clouds

Cloud analysis is partly based on traditional synop information and partly on mulitspectrally classified (SCANDIA model) satellite images from NOAA. Also a simple classification algorithm comparing METEOSAT IR images with 2-meter temperature analyses, is used. As a significant cloud base is not defined in areas with little or no clouds, a field giving probability of observing significant clouds is produced. This makes it possible to distinguish betweem valid and not valid grid-point values.

Wind

The structure functions of 10-meter wind analyses are modelled as a function of distance, but also as a function of normalized roughness length. By this approach we can create and maintain sharp gradients in coastal areas.

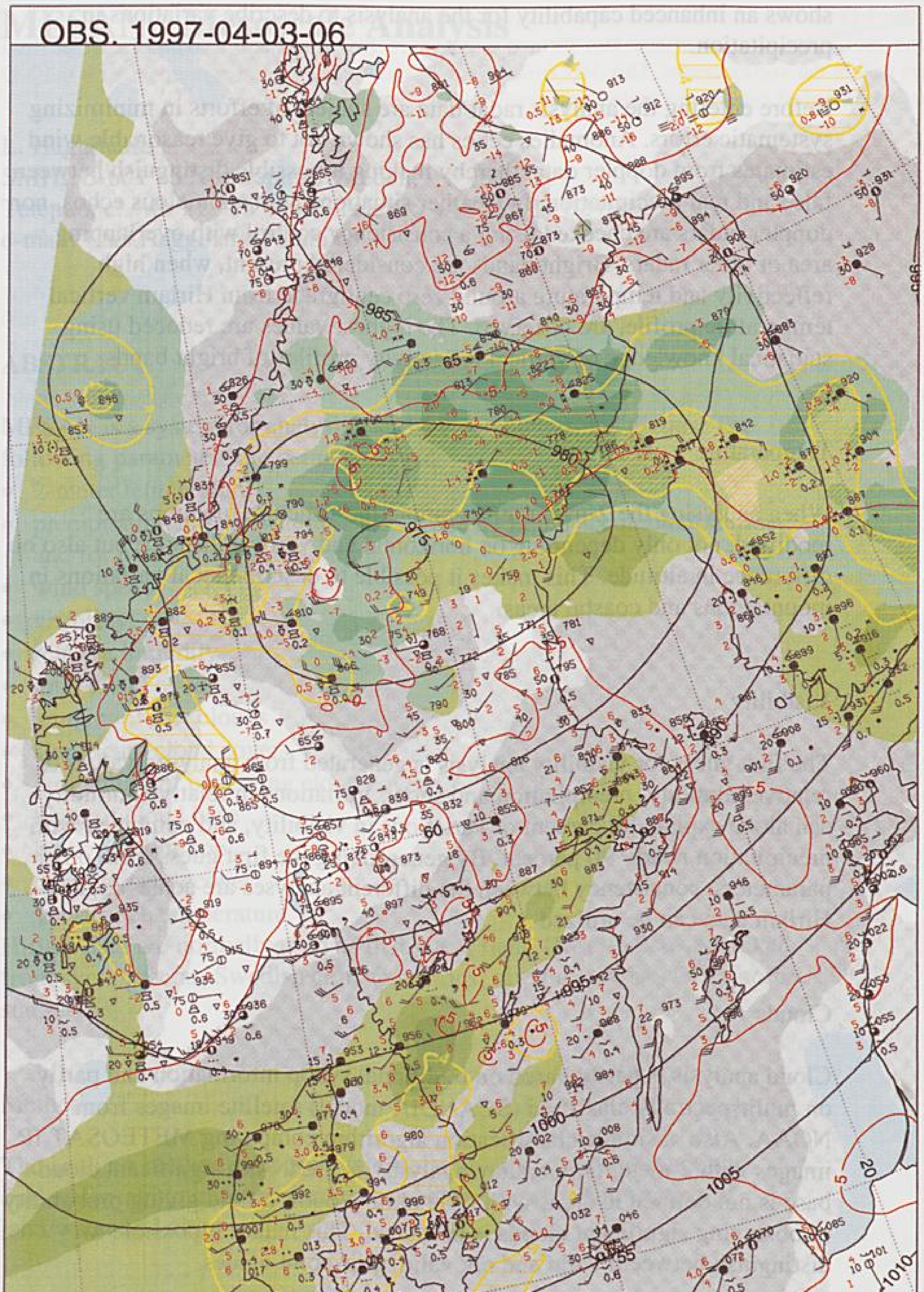

Figure 1. Exemple of output from MESAN. Cloud cover - gray, precipitation - light green, snow - blue green, visibility - yellow, and 2-meter temperature - red. Pressure field is from HIRLAM.

S2

A SYSTEM FOR PRODUCTION OF LOW-LEVEL FORECASTS FOR CIVIL AVIATION

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ABSTRACT

S2 is a Swedish project for the semi-automatic production of low-level forecasts for general aviation. The project, ending in September 1997, is a joint effort between SMHI, Real Time Graphics Ltd of Västerås, Telia Promotor and the University of Lund. The system will be replacing the current one (MET90) which has been operational since 1992.

The system automatically converts a graphic description of the weather situation made by the forecaster into a number of written forecasts. The forecasts are them automatically distributed as meteorological telegrams, converted into computer-generated speech and put onto a telephone answering machine. Once the forecasts are sent the system automatically monitors them in real-time using synoptic observations. If a forecast is incorrect an indication of this is give on the screen.

The techniques used can also be applied to other types of forecasts.

THE LOW-LEVEL FORECAST

Low-level forecasts are mainly used for flight planning by general aviation pilots flying below 12 000 feet (flight-level 125). The forecast has a validity period of 6 hours and describes the weather in detail over most of Sweden. Five forecast are issued daily, the last being a preliminary forecast for the following day. They are continuously monitored and amended if necessary.

The country is divided into 11 districts, each having its own detailed forecast, containing information on weather hazardous to low-level flights (e.g. icing, turbulence, thunderstorms) as well as a general description of visibility, weather, cloudiness, surface winds, winds and temperatures aloft, mean sea-level pressure and the freezing level. Besides a detailed forecast for each district, a descriptive summery of the weather is given for each of the three flight information regions (FIRs) in Sweden.

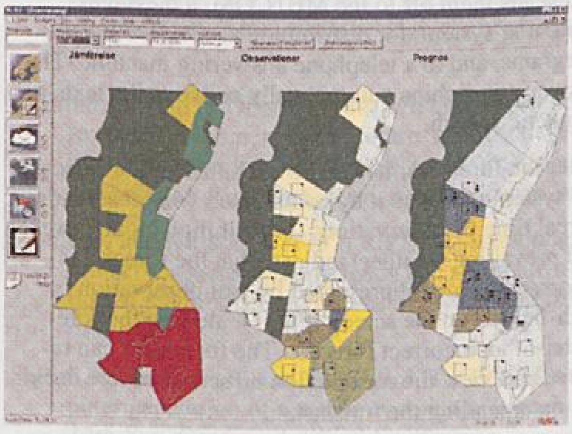

Fig 1: S2 screen for automatic monitoring.

S2

Up until 1992 area forecasts where manually written, monitored and read onto an answering machine - a rather time-consuming process. An interactive, graphic system (MET90) was then constructed to reduce the workload and assist the forecaster in this task. S2 is a further development of this system.

The system will be in operation in September of this year. It will be used by forecasters at the regional offices of SMHI in Stockholm and Sundsvall.

THE CONCEPT

The initial idea behind the system was to "let the forecaster concentrate on the weather and let the system do the dirty work - compile the worded forecast, distribute it and monitor it".

The basis of the forecast (the "first guess") is model output from the Swedish high-resolution limited area model (HIRLAM). The forecaster is also given the option to use the latest observations, the previous forecast or just start off with a "blank sheet". Different first guess alternatives can be used for different forecast elements.

A graphic PC-tool, running under WINDOWS NT, was constructed to assist the forecaster in describing the weather and modifying the first guess fields. As the pictorial forecast progresses, the system constructs a worded forecast in the back-ground. These texts, now written in both Swedish and English, can be viewed at any time during the process.

When the forecaster is content with his/her task and the texts are confirmed, the system formats all the products and sends them off to the METCOM, a messages switching system, for distribution as meteorological telegrams, and to a telephone answering machine. The answering machine automatically converts the texts to synthetic speech.

After the forecaster has approved and sent the forecast, the system monitors it by comparison with observations in real time. If observations (of visibility, cloud cover and prevailing weather) indicate that the forecast is incorrect the area represented by that observation is high-lighted on the screen (Fig. 1), alerting the forecaster of an incorrect forecast. The forecaster can retrieve and view the observation on screen before deciding on amending the forecast.

All in all the system produces of 56 different worded forecasts; 14 products in two different languages and in two different formats, a WMO-telegram format and one suitable for the answering machine.

AUTOMATIC WORDING

S2 enables the forecaster to describe the weather in great detail, both in space and time. In some weather situations, when rapid changes are expected or a number of local variations occur, the amount of information will be so large that if cannot be use in practical flight planning.

The system is capable of describing up to three different zones of weather in each district. If more than three zones are specified, then a condensed forecast is compiled given only the extreme values of forecast elements (e.g. visibility or ceiling).

We use two different approaches when converting the graphic forecast into a written meteorological telegram [Vävargård, T. (1997)]. One is a conventional "canned" approach, using a fixed sentence structure for each language, e.g.

[AREA]: Visibility [VIS] km in [WEATHER] and cloud base [BASE] feet.

The values within brackets are replaced by the forecast values for that particular area.

The other method, used in wording a general descriptive summary of the weather within a FIR, is a novel and innovative approach [Sigurd (1996)]. The summary is constructed by the forecaster by assigning symbols/objects to describe the essential features of the weather situation. The objects are then translated by the system into a universal computer language, *interlingua*. With interlingua as a base, along with a dictionary and a set of grammatical rules, the summary can then be transcribed into an number of different languages.

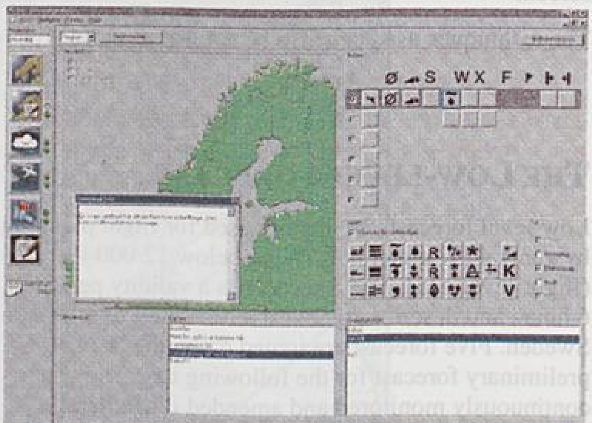

Fig 2. S2 screen for compiling weather summary.

Computer-generated text relieves the forecaster of the non-meteorological task of being a journalist; he/she can completely concentrate on the weather. The structure, language or format (plain language, abbreviated plain language or even GAFOR code) of the forecast can be changed according to new user requirements without affecting the work of the forecaster. From the users point of view the most benefiting advantage of computer-generated text is concise wording. The forecast is always expressed using a limited number of well-known words or expressions.

Text to Speech

Telia Promotor, a subsidiary of Telia, the main Swedish telecommunications company, has supplied SMHI with facilities for converting written text into synthetic speech. The system is capable of handling 11 different languages although the S2 system only uses Swedish and English.

First the written text is "filtered" through a number of lexicons (both user-defined and system lexicons) for transformation into phonetic script. The system then analyses each sentence, applying language-related articulation rules before converting the phonetic script into sound files. Diphone synthesis is applied to the Swedish texts while formant synthesis is used for English.

These sound files are then stored on a telephone-answering machine accessible by the user. With a touch-tone telephone, a pilot can easily choose to listen to an appropriate FIR summary and detailed forecast. The "recording" can be paused at any time for the pilot to note down the information. If needed the sound track can be rewound to the beginning of a section and replayed.

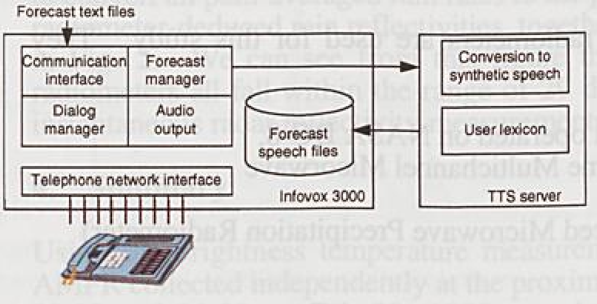

Fig 3. Conversion of text to speech

Future Work

Worded forecasts have their disadvantages, especially when received via telephone. The amount of detail has to be kept within certain limits to be perceptible. Using a graphic representation of the forecast would remedy this disadvantage. Since the detailed low-level forecasts are initially made graphically, this information can fairly easily be presented to the user as a replacement for the worded forecasts or at least as complementary information.

The internet is soon in everyone's home or flying club and would be a cheap way of receiving graphic low-level forecasts. Interactive graphical techniques could also render new possibilities for the user to high-light or sort out information of special interest. Using the new internet "push" techniques the forecasts could be sent directly to a subscribing customer. This would insure that the aviator always has the latest information at hand, be it an scheduled ordinary forecast or a non-scheduled amendment.

Computer-generated synthetic speech is a rather young science. New systems are under development which will improve quality even more. Diphone systems will soon be replaced by polyphone techniques, making the synthetic voice sound even more "human".

Acknowledgements

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Ms. Birgitta Lastow and Prof. Bengt Sigurd for their innovative linguistic contributions.

References

Carlson, G. (1991) MET90, A project for the development of the future Swedish aviation weather system., *Preprints, 3rd Int'l Conf. on the Aviation Weather System,* Amer. Meteor. Soc.

Carlson, G. (1993) Interactive techniques in aviation forecasting. General aviation forecasts using a graphics interface. *Preprints, 1st Eur. Conf. on Applications of Meteorology,* University of Oxford

Hellroth, B., and E. Olsson (1989) MET90, A project for the development of the future Swedish aviation weather system. *Preprints, 1st Int'l Conf. on the Aviation Weather System,* Amer. Meteor. Soc.

Lindh, O. and Nilsson S. (1997) RiPP - A development project for increased efficiency and automatization of the production process in Sweden. *In this preprint.*

Sigurd, B., Lastow, B. and Vävargård, T. (1996) Computer generation of weather overviews. *Preprints, 12th Eur. Conf. on Artifical Intelligence.*

Vävargård, T (1997) RiPP; Autotext and symbol. *In this preprint.*

CROSS-COMPARISON OF AIRBORNE RADAR AND RADIOMETER MEASUREMENTS OBTAINED DURING TOGA COARE

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1. Introduction

The NASA/JPL Airborne Rain Mapping Radar (ARMAR) onboard the NASA DC-8 aircraft, several airborne multi-channel radiometers onboard the NASA ER-2 aircraft, and the doppler radars onboard the NOAA P-3 aircraft were deployed for rainfall observations collected over the Western Pacific Ocean during the TOGA/COARE experiment in January and February of 1993. Several coordinated flights in which near-simultaneous observation of the same rain system by these instruments were conducted during this period. The rain systems observed included isolated convective cells, mesoscale convective complexes, and a tropical cyclone. In this paper, we use the co-located brightness temperature measurements collected by three different radiometers to estimate the radar reflectivities for that particular flight leg. We then compare these radiometer-deduced results with the rain reflectivity measurements of all ARMAR radar to check the radar reflectivity measurement consistency.

Nadir brightness temperature measurements of three radiometers are used for this study. They include measurements of:

(1) the 13.8-GHz ARMAR's radiometer channel operated on NASA DC-8,
(2) the 18-GHz channel of the AMMR-1 (Airborne Multichannel Micorwave Radiometer) operated on NASA DC-8, and
(3) the 10.7-GHz channel of the AMPR (Advanced Microwave Precipitation Radiometer) operated on NASA ER-2

Over the time of interest, there are 170 ARMAR radiometer's nadir measurements, 328 AMMR's nadir measurements, and 113 AMPR's nadir measurements.

2. Conversion of Brightness Temperature to Rain Rate

The brightness temperature (T_b) measurements of ARMAR and AMMR are converted to the one-way path-integrated attenuation (*PIA*) using the empirical formula (Durden, et al., 1994):

$$PIA_{ARMAR,AMMR} = 0.34 + 0.000192\,(T_b - 125)^2 \quad (1)$$

Whereas, the brightness temperature measurements of AMPR are converted to the one-way path-integrated attenuation using the X-band model developed by Weinman et al. (1990):

$$PIA_{AMPR} = 7.12 - 1.42\,\ln\,(263.3 - T_b) \quad (2)$$

The deduced *PIA*s of all three radiometers are divided by 4.5 km, the mean rain cell height over this flight leg, to get the averaged attenuation coefficient (K, in dB/km). Here, we have assumed that the rain itself is spatially uniform so that the derived attenuation coefficient represents the path-averaged value.

Next, the path-averaged attenuation coefficients are converted to the path-averaged rain rates (R) using the K-R relationships derived by logarithmic regression of the Mie scattering calculations (Olsen et al., 1978). Specifically, the following relationships are used for this study:

$$K_{ARMAR} = 0.0268\ R^{1.118} \tag{3.a}$$

$$K_{AMMR} = 0.0173\ R^{1.143} \tag{3.b}$$

$$K_{AMPR} = 0.0719\ R^{1.097} \tag{3.c}$$

The path-averaged rain rates deduced for the three radiometers range between 2 and 9 mm/hr and they match quite well with one another. To quantify how well these three deduced data sets match one another we plot their scatterograms in Fig. 1. In order to have the same number of data points for constructing the scatterograms, we use the AMPR rain rate data (with the smallest number of data points) as reference and use only those ARMAR and AMMR rain rate data that are deduced from brightness temperature measurements collected at times closest to those of AMPR data. We can see that these three sets of deduced rain rates indeed correlate quite well, with correlation coefficient values of at least 0.9.

3. Conversion of Path-Averaged Rain Rate to Rain Reflectivity

We use the Marshall-Palmer type Z-R relationship of the form

$$Z = 10 \log (200\ R^{1.6}) \tag{4}$$

to convert all path-averaged rain rates to the path-averaged rain reflectivity. The histograms of the radiometer-deduced rain reflectivities, together with the radar-derived rain reflectivities, are shown in Fig. 2. We can see from this figure that the deduced path-averaged Z values of the three radiometers all fall within the range of 29 dBZ and 39 dBZ, and they agree very well with the instantaneous radar reflectivity measurements obtained by ARMAR.

4. Summary

Using the brightness temperature measurements of ARMAR radiometer channel, AMMR, and AMPR collected independently at the proximity of the radar reflectivity measurements between UT 23:33 and 23:39 on Feb 20, 1993, we deduce the path-averaged rain reflectivity. Our results indicate that the range of path-averaged rain reflectivities deduced from the radiometer measurements all fall within the range of 29 dBZ and 39 dBZ, which are in good agreement with the instantaneous radar reflectivity measurements obtained by ARMAR.

The consistency between the brightness temperature-deduced path-averaged rain reflectivities and the instantaneous ARMAR's radar reflectivity measurements is expected because the brightness temperature measurements of all three radiometers were collected at the same viewing geometry as ARMAR's radar measurements. The P-3 radar reflectivity measurements, which were collected at horizontal viewing of the rain cell, are lower due to non-spherical raindrop shape, radar polarization difference, and larger path-induced attenuation (longer rain path).

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References

Durden, S. L., Z. S. Haddad, E. Im, F. K. Li, A. B. Tanner, and W. J. Wilson, 1994: Measurement of rainfall path integrated attenuation at nadir : a comparison of radar and radiometer methods at 13.8 GHz. In preparation.

Fujita, Masaharu, K. Okamoto, H. Masuko, T. Ojima, and N. Fugono, 1985: Quantitative measurements of path-integrated rain rate by an airborne microwave radiometer over the ocean. *J. Atmos. Oceanic Tech.*, **2**, 285-292.

Oguchi, T., 1983: Electromagnetic wave propagation and scattering in rain and other hydrometeors. *IEEE Proceedings*, **71**, 1029-1078.

Olsen, R. L., D. V. Rogers, and D. B. Hodge, 1978: The aRb relationship in the calculation of rain attenuation. *IEEE Trans. Ant. Propag.*, **AP-26**, 318-329.

Weinman, J. A., R. Meneghini, and K. Nakamura, 1990: Retrieval of precipitation profiles from airborne radar and passive radiometer measurements: comparison with dual-frequency radar measurements. *J. Appl. Meteor.*, **29**, 981-993.

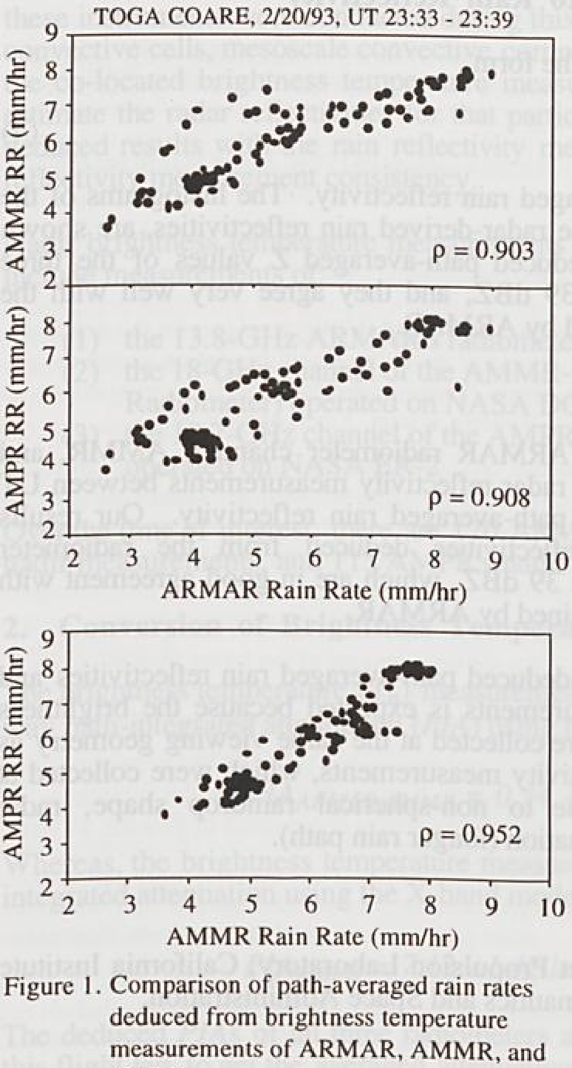

Figure 1. Comparison of path-averaged rain rates deduced from brightness temperature measurements of ARMAR, AMMR, and AMPR .

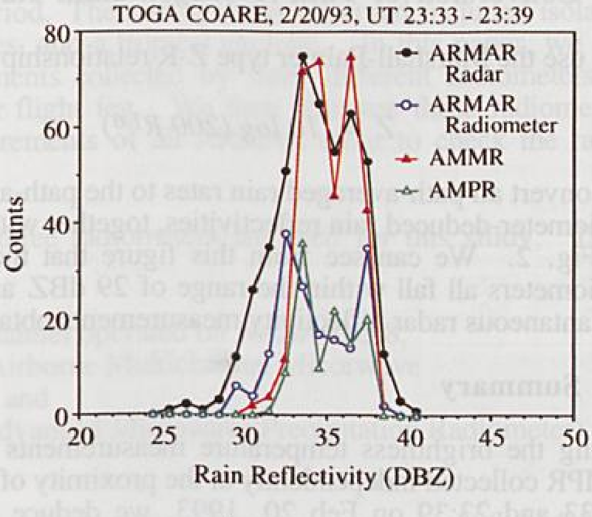

Figure 2. Histogram of rain reflectivity deduced from ARMAR radar backscatter measurements and brightness temperature measurements of ARMAR, AMMR, and AMPR .

OBSERVATIONS AND FORECASTS - INTERPRETATION AND PERCEPTION

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ABSTRACT

1. Introduction

The value of information to users depends upon: (a) how well it is understood; and (b) how it affects their decision making. As operational meteorologists in an increasingly commercial environment (Tennekes, 1988), we wish to maximize the benefit to our customers in both these areas. Information is perceived differently by different user groups, that is perception is in the mind's eye and depends on the user's viewpoint. Anaman and Lellyett (1996) summarized the attributes which define the quality of information as: (a) relevance; (b) level of detail; (c) accuracy; (d) impartiality (or degree of trust); (e) convenience; and (f) timeliness. All these areas need to be addressed when arranging the provision of meteorological services.

McCallum & Mansfield (1996) point out that some good forecasts have been degraded by the wrong emphasis. However, as users perception varies, so must the emphasis.

2. Assimilation of data by the forecaster

Traditionally using graphical hard copy, the military aviation forecaster is increasingly reliant upon visual display units. Using the UK Met Office 'Outstation Display System', model fields can be overlaid on satellite images to verify model guidance, for example. Indeed, with the introduction of the faster Weather Information Network by the UK Met Office, a greatly increased amount of imagery and numerical weather prediction (NWP) products have become available to the outstation forecaster. Kurz (1994) pointed out that in order to make optimal use of these NWP products it is necessary to interpret them correctly. To help in the use of these data, the UK Met Office College runs courses in 'Numerical Weather Prediction Application' and 'Satellite Imagery Interpretation'. McCallum & Mansfield (1996) gave an overview of the current forecasting process.

Coded data can be accessed rapidly using an alphanumeric terminal - much quicker than searching through large amounts of teleprinter paper which was the norm until a few years ago. However, the quality of the data needs to be assessed by the forecaster. Recent changes include the increasing number of 'automatic' observations available. These differ from 'traditional' observations in several ways. For example:

(a) A ceilometer cannot report orographic cloud on a distant hill which may, nevertheless, affect approaching aircraft.
(b) Precipitation may adversely affect laser cloud base reports.
(c) When patchy fog occurs, a visibility sensor cannot report adjacent fog. On the other hand, the sensor itself may be in a fog bank when the surrounding area is clear.
(d) In heavy showers, the sensor may underestimate visibility.

In other words, inhomogeneities in the atmosphere mean that the human observer and the automatic instruments are reading different things. This discrepancy needs to be taken into account by the aviation forecaster.

3. Probabilistic and ensemble forecasting

Harrison (1995) addressed the problems of how ensemble forecasts should be used and this may become an increasingly important part of the Numerical Weather Prediction Application Course run by Met Office. However, probability forecasts may sound scientific but mean little to the general public (Thornes, 1996).

4. Customers' needs

Stubbs (1996) listed the principal customers for weather forecasts: (a) severe weather warnings for central government; (b) shipping; (c) aviation; (d) commercial organizations; (e) public utilities; (f) educational establishments; and (g) individual customers requiring forecasts for specific purposes. All these customers have different requirements and expectations. For the maximum benefit to be realized, users need to be educated. As Ballentine (1994) put it, "users need to be made aware of what information is available and how they can use it". Similarly, the service provider needs a thorough knowledge of his customers business and of the market place. The greatest benefit is therefore obtained through a partnership between user and provider.

5. Customers' understanding

As already outlined, the customers perception of the forecast is all important but this depends on the type of customer.

5.1 Media and general public

Great improvements have been made in the display systems used for media presentations in recent years, but the usefulness of the package to the end user still depends on perception (McCallum & Mansfield, 1996). However, it can be argued that TV viewers really want to see "clowns to cheer them up" (Tennekes, 1988) and are less interested in the information content. This entertainment factor can be verified by the viewing statistics.

5.2 Specialist customers

Training of the customer (see Ballentine, 1994) is carried out on a formal basis in the military aviation field. Meteorology is a fundamental part of 'ground school' and training of pilots is carried out by experienced meteorologists. Similarly, the forecasters themselves are trained in the particular requirements in 'Defence Briefing Workshops'.

The pilot may be unaware, however, that although favourable conditions are forecast in a Terminal Aerodrome Forecast (TAF), the TAF does not need to be amended unless the colour state changes. More difficult to address is the problem of low flying in marginal conditions when the cloud base is diffuse. Visibility and cloud base (as measured from the ground) may be 'above limits' but conditions immediately below the cloud base may be very poor. There is no way to describe this formally in a route forecast or significant weather chart.

5.3 Face to face briefings

Most communication has been shown to be non-verbal. By a face to face briefing, the forecaster may convey important messages, such as confidence in the forecast, by non-verbal signals. The telephone is therefore fraught with difficulties, even if the text of messages is read back. The 'Remote Forecaster Trial', undertaken by the UK Met Office, failed for this reason.

Over a period of time, pilots and station authorities build up a relationship with their meteorological staff and much greater value is obtained from the service as a result. For example, the forecaster will know instantly which element of the weather is of critical value to each particular customer.

6. Perception of forecast verification

Thornes (1996) suggested that it should be recognized that the quality of a forecast is dependent upon what the client wants and therefore the target accuracy cannot be the same for all weather forecasts. Also a statement such as '85% accurate' is meaningless without clear specification (Murphy, 1991). As Murphy also pointed out, overall measures of model performance, as surrogates for measures of forecast quality, should not be used just because the figures are readily available. But the rules governing the verification of even quite simple forecasts, such as military aviation warnings, are so complicated as to confuse the meteorological specialists. What then, is the customer to make of it?

In order to simplify the verification, the UK Met Office Airfield Forecast Verification scheme requires a special forecast to be prepared for verification purposes which is not disseminated to customers. A figure is achieved but this is still not necessarily the best measure of usefulness. This criticism also applies to the assessment of warnings. Not all warnings assessed are important for all users and some vital ones are not assessed (severe airframe icing, for example).

7. Conclusion

The language of aviation forecasts is clearly defined in regulations governing their preparation. However, it is impossible to be completely objective. The emphasis and language of the forecast should be dependent on the requirements of the final end user.

Personal face to face contact is of immense value in maximizing the benefit of the meteorological service to the user, even when agreed definitions and a common language is used. The meteorologist requires a thorough knowledge of the customer's business. Education of the user is helpful in two ways: (a) an understanding of the facilities available and the likely limits of forecast accuracy; and (b) conceptual models assist in the retention of information (for example 'the cloud is high today because the air is dry').

The role of the meteorologist is to explain as well as describe the weather to the customer.

References

Anaman, K. A. & Lellyett, S. C. (1996). Producers' evaluation of an enhanced weather information service for the cotton industry in Australia. *Meteorol. Appl.*, **3:** 113-125.

Ballentine, V. (1994). The use of marketing principles to maximize economic benefits of weather. *Meteorol. Appl.*, **1:** 165-172.

Harrison. M. (1995). *Ensemble forecasting in the medium, monthly and seasonal time ranges.* Second European Conference on Applications of Meteorology. Conference Documentation, Meteo-France, 212-215.

Kurz, M. The role of diagnostic tools in modern weather forecasting. *Meteorol. Appl.*, **1:** 45- 67.

McCallum, E. & Mansfield, D. (1996). Weather forecasts in 1996. *Weather,* **51:** 181-188.

Murphy, A. H. (1991). Weather forecast assessment: Accuracy or quality? *Weather,* **46:** 180.

Stubbs, M. W. (1996). Future developments in weather forecasting. *Weather,* **51:** 188-191.

Tennekes, H. (1988). Numerical weather prediction: Illusions of security, tales of imperfection. *Weather,* **43:** 165-170.

Thornes, J. E. (1996). The quality and accuracy of a sample of public and commercial weather forecasts in the UK. *Meteorol. Appl.*, **3:** 63-74..

OBJECTIVE WEATHER FORECASTING

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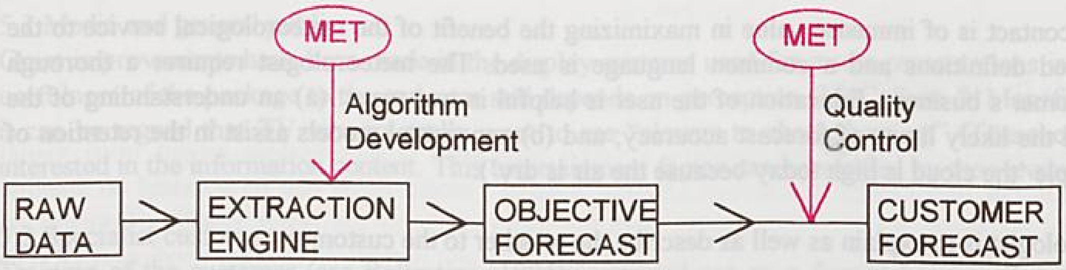
ABSTRACT

Meteorological Operations depend on observational data and Numerical Model output in order to generate weather forecasts. We define a "basic" level of data as Numerical Model output, traditional observations (SYNOP & TEMP data), satellite and radar imagery.

Working with a "basic" level of data, it is possible for the human forecaster to generate each forecast from first principles, to meet the demand of the customer.

An alternative route to operational weather forecasting involves an automated approach, where NWP Model fields are used as input to an "Extraction Engine". At the heart of the Extraction Engine are meteorological algorithms which are used to determine the Objective Forecast. The output is then in the form of site-specific forecasts of any meteorological parameter which can be modelled numerically. The Extraction Engine output constitutes an objectively-based "enhanced" tier of data.

Forecasting Operations



Raw NWP model data is used as the input to the Extraction Engine. The meteorological intelligence of the Extraction Engine is defined by the meteorological algorithms, which are used to generate the enhanced tier of data, or objective forecast.

The human forecaster, or "met", in the above flow diagram is currently employed at two stages of the forecasting process. The first stage is the development of the algorithms, which is a non-operational research and development effort. The second stage is in regular, day-to-day operational Quality Control of the post-extraction process.

Traditionally, forecasters would produce each and every forecast, but the objective forecast process only requires intervention by a forecaster when necessary. i.e. if the objective forecast is deemed to be skilful by the duty forecaster, then no intervention is required and the forecast generation process is totally automatic. If the objective forecast is deemed to be in error, then the duty forecaster can manually edit the forecast, thereby adding meteorological value. Compared to a traditional forecasting process, the objective forecast approach allows better deployment of human resources.

Extraction Engine - system architecture

NWP data is ingested from a global model of 1.25 degree horizontal resolution and the incoming data resides in a datastore for access by all systems - the data being in GRIB (Gridded Binary) format.
The extraction engine user interface gives access to certain parameters that need to be set before running the software, such items being valid time of model data, the period(s) when a site specific forecast is required, which location(s) is a forecast required for etc. This interface has been installed within the current workstation architecture allowing the forecaster to have an extra option to create an automated forecast, the overall effect being to enhance the workstation's capabilities and increase it's flexibility.
A graphically enhanced version of the workstation (weatherproducer) creates broadcast-ready graphics for television use and the output of the extraction engine has been designed such that it can interface directly with the weatherproducer to automatically build TV forecast graphics. The output of the engine is in the form of forecast fields which consist of a combination of meteorological parameters. Together, these parameters define the expected weather conditions at a point in time and space, the field containing such parameters as wind direction and speed, type and amount of precipitation, cloud cover etc.
The site-specific forecasts created by the engine are stored back in a second datastore, again accessible by all networked workstations.

Extraction Engine - meteorological intelligence

The general method used by the engine is that commonly described as the Perfect Prog. technique; i.e. model data is assumed to be correct and is used as predictors to create the forecast datum at each specified site and time.
The term "Extraction Engine" describes the initial step of the automated forecast process. Once a forecast has been requested, the appropriate model data is then accessed from the datastore and various parameter values are then extracted from the model fields at the time and location in question. These parameters will be such items as surface pressure, 500mb vorticity, 850mb temperature etc.
A set of meteorological rules or algorithms have been written, (and are being developed further) through which the model data is then passed. Each cluster of algorithms has been designed to forecast one particular parameter - an example being precipitation type, the output being rain, sleet or snow.
The overall design of the automated forecast process has been such as to allow a comprehensive forecast for any location to be produced, the forecast field containing an array of derived variables such as stability parameters, wind-chill calculations and so on. Obviously this makes for a much more versatile set of forecast information that can be put to many different uses.

Extraction Engine - development

Development of the Extraction Engine involves addressing the following:

- Meteorological development to enhance Forecasting performance;
- Software development to enhance operational and commercial applications;

The Meteorological Intelligence of the Extraction Engine is enhanced by managing a development program designed to provide Global Forecasting capability, Local Forecasting capability, and an enhanced tier of data over and above the basic dataset.

At the heart of the Meteorological Development of the Extraction Engine is an on-going objective forecast verification program. This program is designed to indicate which areas of the current operational algorithms require attention, and therefore assists in the decision-making process for deployment of Meteorological research personnel. The verification scheme itself is treated as an on-going development effort, with regular assessment and subsequent upgrading.

In addition to meteorological intelligence development, systems and software development is geared towards providing a commercially and operationally applicable forecasting tool. This includes development of an interactive editor which enables the operational forecaster to adjust the basic model data during the pre-extraction process, or the objective forecast during the post-extraction process.

AN AUTOMATED SCHEME FOR PREDICTING MOUNTAIN WAVE INDUCED TURBULENCE FOR CIVIL AVIATION

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1 Introduction

The UK Meteorological Office (UKMO), one of two World Area Forecast Centres (WAFC), has a responsibility to provide aviation forecasts for mid and upper levels across the globe. As such, there is great motivation to develop methods for improving the prediction of Clear Air Turbulence (CAT). The economic savings which can be made from accurate turbulence forecasting provide a strong case for the development of automated turbulence prediction algorithms to replace current more subjective methods. Work has already been carried out towards developing prediction algorithms for CAT due to jet streams (Halsey *et al.*, 1997).

Gravity wave activity induced by mountains is a significant yet poorly addressed cause of CAT to civil aircraft at cruising levels. The Commission of Aeronautical Meteorology (CAeM) Working Group on Advanced Techniques Applied to Aeronautical Meteorology stated in their final report (1995) that:

> *"Breaking waves constitute one of the most serious turbulence hazards to high-level flight, liable to result in airframe damage"*

The report highlighted the need for improved parameterisation of mountain wave behaviour in global forecast models, and for the development of prediction algorithms suitable for use in aviation forecasting. Although mountain wave activity and its turbulent effects have been extensively studied using high resolution models, current forecast models cannot represent such small scale features adequately. However, in developing operational prediction systems, the use of operational NWP products is highly desirable.

In this study, the parameterisation of gravity wave drag in the UKMO Unified Model is used in an initial comparison between model diagnostics and actual turbulence reports obtained from affected aircraft. A case study over the Alps region will be presented, where model data and aircraft reports will be used in a statistical comparison on two contrasting days, illustrating high and low turbulent activity respectively. The Alps region was selected due to its highly variable topography, which makes the area particularly susceptible to mountain wave turbulence (MWT), and its position on busy air traffic routes to and from central Europe.

The principle diagnostic used in this comparison is gravity wave stress, which is an indicator of the likelihood of gravity wave breaking, and is highly dependent on orography and meteorological conditions. Data for the comparison were collected from two sources; an archive of automated ASDAR reports, and from direct pilot reports of turbulent conditions while crossing the Alps at high levels.

2 The Gravity Wave Drag scheme in the UKMO global NWP model

The formation of gravity waves occurs when the wind direction is perpendicular to the orientation of an orographic ridge. Under stable atmospheric conditions, the forced upward motion of the flow becomes trapped, and a downwind lee wave results. Energy is also propagated vertically from the ridge in the form of gravity wave stress, which approaches critical levels as height increases. When the stress exceeds a critical value, dependent upon local wind speed, static stability and density, the wave 'breaks' and a drag force is exerted on the atmosphere according to

$$\frac{\partial u}{\partial t} = g\frac{\partial \tau}{\partial p}$$

where τ is the stress in Nm^{-2}, and $\partial u/\partial t$ is the corresponding deceleration of wind.

Since the calculation of this critical value depends on the local wind, the greater the vertical wind shear between two levels, the more likely wave breaking, and hence turbulence is to occur. This parameterisation is used in the global model to maintain accurate wind fields. Recent improvements to the parameterisation (Milton *et al.*, 1994) include the use of anisotropic orography, based on recommendations by Shutts (1990).

Global plots of gravity wave stress show areas of high values over mountains and in the winter hemisphere. The strength is dependent more upon the variability of the topography than the mountain heights themselves. The scheme does not allow for any horizontal propagation of the energy, so there is no representation over ocean areas. Since the orientation of the ridge of the Alps is east-west, most gravity wave activity would be expected to occur when winds are northerly or southerly.

3 Aircraft turbulence reports

The UK Meteorological Office has held, since 1993, an archive of automatic reports from aircraft equipped with Aircraft to Satellite Data Relay (ASDAR) systems. These systems are carried by some wide-bodied jets, and reports of meteorological conditions are relayed every seven minutes. Parameters reported include a CAT indicator, which reports zero, light, moderate or severe CAT, which are derived from the ratio of the normal acceleration experienced by the aircraft and gravity. The advantage of these reports is that they are fully automatic, and therefore objective, and that zero reports are also included, thereby positively identifying non-turbulent conditions for large aircraft. However, since only large aircraft contribute to this dataset, turbulence events which may be hazardous to other aircraft may pass undetected.

The other data source used for this study were pilot reports of turbulence over the Alps region, supplied by Lufthansa. The position co-ordinates and time are reported along with flight level, wind readings and an indication of the severity of turbulence. These have the advantage of including all sizes of aircraft, not just large jets as with the ASDAR reports. However, they lack the inclusion of negative reports, and are subject to human interpretation, and as such are inherently subjective.

4 Case study

The log of turbulence reports was used to identify one day where many positive turbulence reports had been recorded, and one day with relatively few. Model derived gravity wave stress data for both days was obtained for the relevant heights and times of the observations. Figure 1 shows a representative contour plot of the model data with the positions of turbulence reports and corresponding wind vectors superimposed.

A value for gravity wave stress at each reporting position and time was assigned, using interpolation from the nearest grid points and forecast time of the model runs. These values were then used to construct a contingency table to compare model values with occurrence of positive reports (Table 1). A cut-off value of 0.01 Nm^{-2} was used.

Gravity wave stress values	**> 0.01 Nm^{-2}**	**< 0.01 Nm^{-2}**
Turbulence reports	12	2
Zero reports	291	552
Total reports = 857 (11 pilot, 846 ASDAR)		

Table 1: *Contingency table comparing actual and model estimates of turbulent activity*

Figure 1 shows the strong relationship between wind direction and gravity wave stress. The high values over the Alps ridge in northerly flow (1a) contrasts sharply with low values in easterly flow (1b). The positions of the positive turbulence reports correspond well with the high values of stress, with values greater than those observed in the easterly flow conditions. Table 1 shows a hit rate of 85.7%, whereby all but 2 positive reports lay in a high stress area, while the false alarm rate was 96%, indicating high incidence of zero reports in this region.

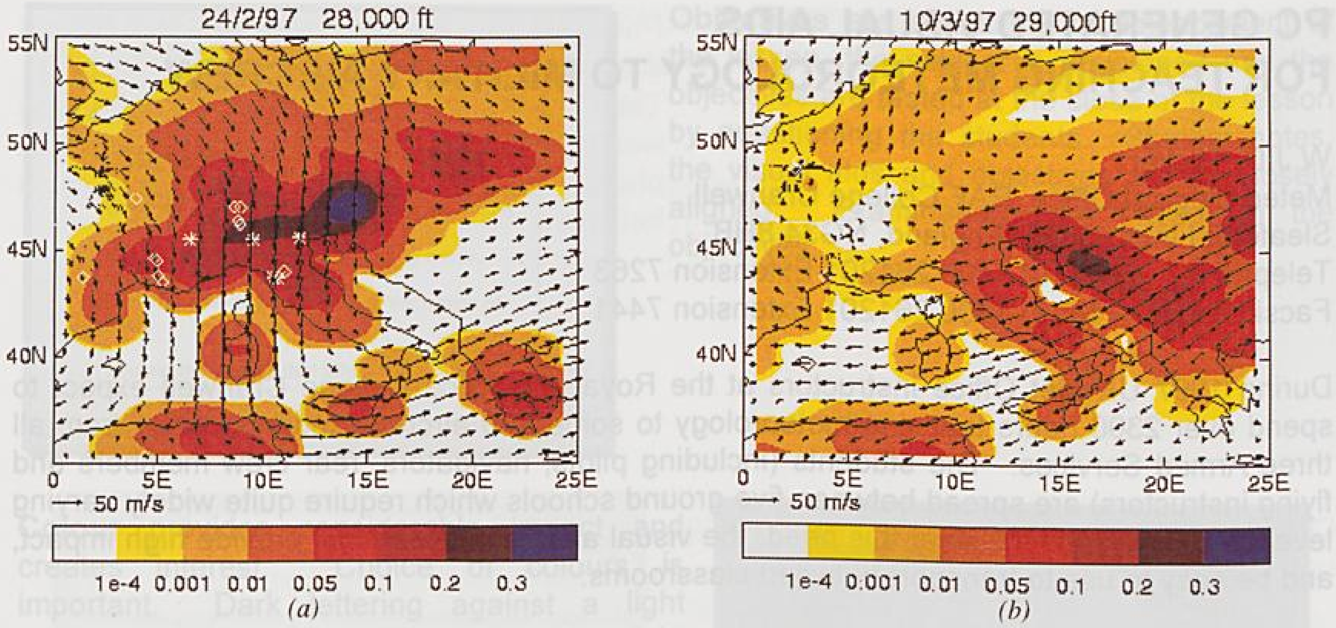

*Figure 1. Plots of gravity wave stress (Nm^{-2}) on a) 24/2/97 for high incidence of turbulence and b) 10/3/97 for low incidence. Contours have been smoothed across grid points. Dots indicate zero values, diamonds indicate light turbulence, and * indicate moderate or severe turbulence. Wind vectors are shown for the levels corresponding to the gravity wave stress data.*

The high false alarm rate is not of great concern. On this scale, the model resolution is coarse, with only around 50 grid points covering the immediate Alps region. The inherent heavy smoothing, and the non-resolution of the highest peaks act to decrease the magnitude of the peak stress output, while masking smaller areas and discontinuities where stress is reduced. These can occur when the wind direction turns through 90° from the surface direction, reducing the stress value to zero.

Thus, the use of such a model can only indicate areas of potential turbulent activity, rather than definitively predict it. The advent of the increased resolution of the global grid in future will go some way to resolve this. Clearly, a small sample was used in this study, and rigorous statistical analysis would require a large dataset of model information and reports.

5 Conclusions

It has been shown that the UKMO gravity wave stress parameterisation may be used in the development of mountain wave turbulence prediction algorithms. However, the coarseness of the current grid remains a limitation, since interpolation may not give a best estimate of the gravity wave stress between grid points. Ability to predict turbulence encounter probability, rather than specific events is a more realistic aim.

The initial results from this study provide insight into the steps which need to be taken to further develop a MWT prediction algorithm. Other diagnostics from the scheme, such as wind drag may provide improved correlations, along with the use of a large number of samples.

6 References

Milton, S.F., Wilson, C., Stratton, R.A., Hammon, O., Rawlins, F. 1994. Impact of a new gravity wave drag scheme and orographic roughness in the Unified Model. I. Global model tests. UK Meteorological Office Technical report No. 127.

Shutts, G.J., 1990. A new gravity wave drag parameterisation scheme for the Unified Model. Turbulence and Diffusion Note 2. Available form APR Division, Meteorological Office.

Halsey, N.G.J., McHaffie, A., Forrester, D.A., Lunnon, R.W. 1997. Seventh Conference on Aviation, Range and Aerospace Meteorology, 2-7 February 1997, Long Beach, California.

PC GENERATED VISUAL AIDS FOR TEACHING METEOROLOGY TO MILITARY AIRCREW

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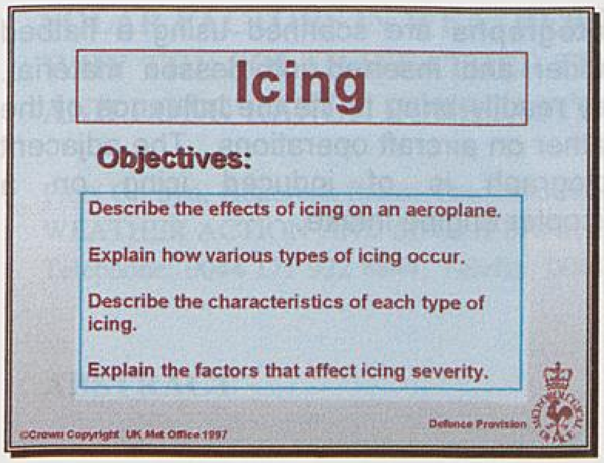
During 1997 UK Met Office instructors at the Royal Air Force College Cranwell expect to spend over 2300 hours teaching meteorology to some 800 aircrew students drawn from all three Armed Services. The students (including pilots, navigators, rear crew members and flying instructors) are spread between five ground schools which require quite widely varying levels of instruction. To meet this need, the visual aids employed must provide high impact, and be easy to use to transport between classrooms.

In order to accomplish this large workload efficiently and effectively, the visual aid material has been developed on a personal computer using MS PowerPoint software. This software is standard in classrooms and in the Met Office where the lessons have been developed. Most ground schools at Cranwell have excellent classroom projection facilities which are driven by a PC under the control of the instructor. Slide shows are projected either via large screen monitors or through LCD projectors onto large flat screens. Earlier projectors gave good results in an almost darkened room but the latest projectors provide excellent colour, density and brightness even with some ambient light - an important consideration since the instructor requires both visual and audio feedback from his students. Remote control facilities are sometimes available, thus allowing the instructor to move more freely around the classroom.

Since early 1994, the Senior Met Officer at Cranwell has been converting visual aid lesson material to PowerPoint format and taking advantage of its software facilities to develop concepts that were previously difficult to illustrate using overhead projector transparencies. In the last year or so he has been assisted by other members of staff so that now most of the required topics are available for easy use. As a result, overhead projector facilities are only used in less than 10% of the lessons taught. Other than the instructors' notes, a floppy disk is all that needs to be taken to lessons. Examples of subjects covered include airframe icing, turbulence, thunderstorms, visibility, airmasses and fronts with the main emphasis being on flight safety.

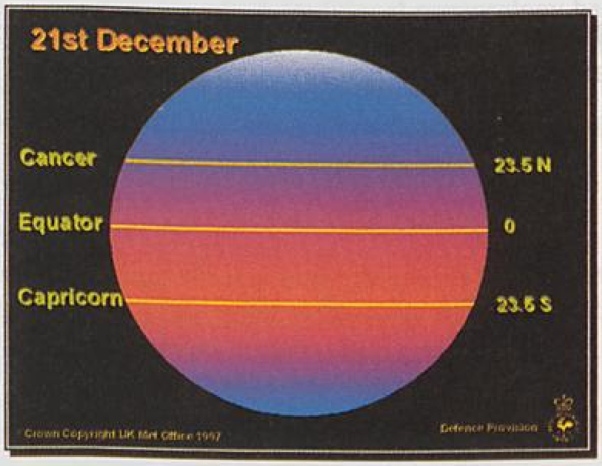
The software was primarily designed for business applications but has been successfully used to provide visual impact for meteorological instruction. When generating lessons for military aircrew, a strict lesson plan and outline have to be followed. Once the time-consuming process of generating the basic visual aid material in computer format is complete, it is relatively simple to expand lessons to incorporate additional topics, where the syllabus demands. Before using a particular lesson the instructor can tailor it to suit his needs by quickly rearranging the slide order or hiding unwanted slides. He can also generate additional material and so enhance the lesson for future use.

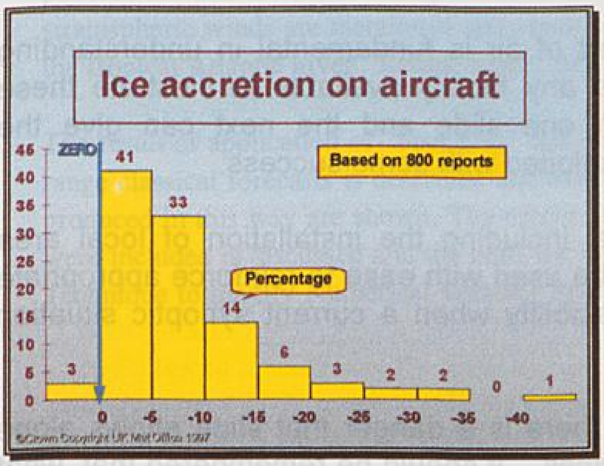
Some of the facets of the visual aid material are discussed and illustrated on the following pages.



Objectives are set at the commencement of the lesson, the subject is developed and the objectives are tested at the close of the lesson by questioning the students. Student notes, the visual aids and objectives are all closely aligned. Examinations are based on the objectives.

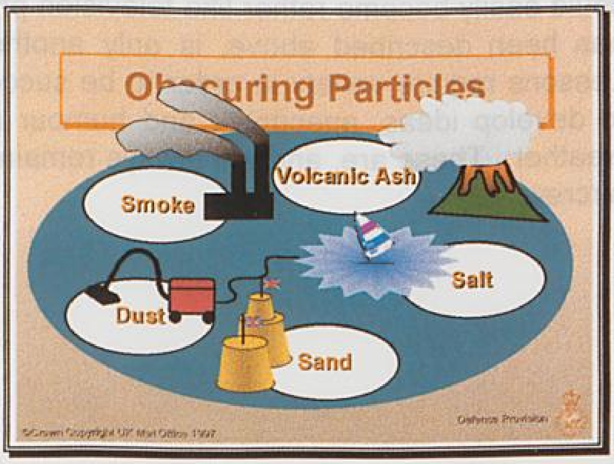
Colour provides considerable impact and creates interest. Choice of colours is important. Dark lettering against a light background is successful although light lettering on a dark background will also provide contrast. Colours can be used to highlight particular topics or reinforce an idea.

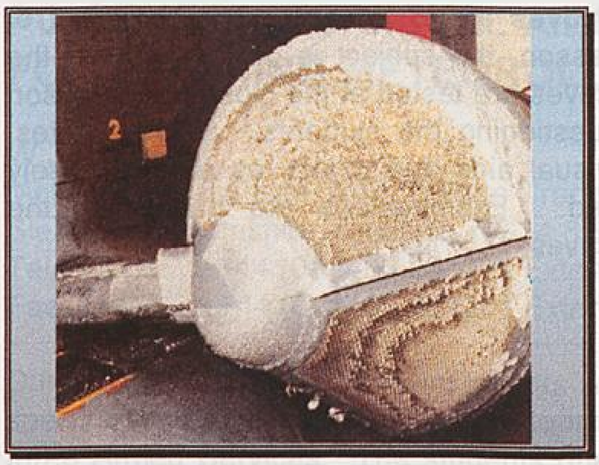




Graphs are inserted to emphasise particular points. This slide illustrates the frequency of icing (mostly airframe icing) for given temperature ranges. The data were first entered into a computer data sheet and then the form and colour of the displayed graph were selected.

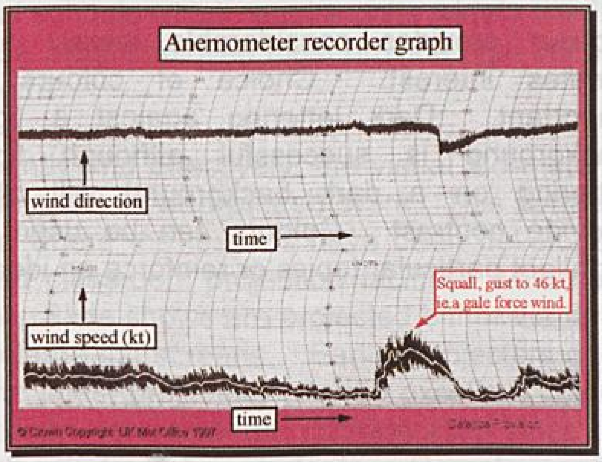
Clipart can be imported into the slide show to bring across a particular point. This is an example from a lesson which highlights the problems of slant visibility for pilots and navigators





Photographs are scanned using a flatbed scanner and inserted into lesson material. They readily bring to life the influence of the weather on aircraft operations. The adjacent photograph is of induced icing on a helicopter engine intake.

Charts or similar meteorological information can also be incorporated using a scanner.



A knowledge of vertical and horizontal **movement** of air is fundamental in understanding meteorology. The software used does not have any facility available to illustrate these processes. However, the "transitions" between one slide and the next can give the impression of movement. This facility has been exploited with some success.

Current and future communication developments, including the installation of local area networks, should mean that satellite imagery can be used with ease to reinforce appropriate topics. The use of "live" weather is another possibility when a current synoptic situation proves beneficial to the learning process.

Given the quality of the graphics now available, there is a danger that slide shows alone could easily become rather like television programmes,. It should be remembered that, what has been described above, is only another tool available to the meteorology instructor. Lessons require variety in order to be successful and should include use of the whiteboard to develop ideas, anecdotes and humour and visits outside to view and discuss the real weather. These are, and will always remain, the main requirements of a complete lesson for aircrew.

SOLAR FACTORS IN WEATHER FORECASTING - WHY THE SOLAR WEATHER TECHNIQUE WORKS IN SHORT; MEDIUM AND LONG RANGE FORECASTING

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ABSTRACT

WHY DO WEATHER FORECASTS GO WRONG? is a question for which traditional meteorology has no clear answer beyond saying "statistically some just will". The revolutionary Solar Weather Technique (SWT) of long range forecasting uses factors originating in solar activity to make long range forecasts many months ahead down to details of a few days. The forecasts are now used for commercial planning purposes by leading companies in Britain and Europe, and have a proven independently assessed track record of accuracy.

The inadequacies of the ensemble approach of classical meteorology to long range prognosis is discussed and mechanisms whereby predictable weather development takes place which puts actual weather outside the range of "reasonably expected" classical possibilities is outlined.

Evidence for periodicity in weather and atmospheric phenomena which match signals in solar activity is put forward and the basic concept of the Solar Weather Technique outlined. Modulation effects of stratospheric winds are mentioned and results of forecasts of weather phenomena in Britain, Europe and the tropical Atlantic given. Recent results of direct prediction of major solar events are also presented.

The result of application of "Speed-up" and "Slow-down" solar factors to improve existing medium range classical forecasts is described and examples of publicly available commercial forecasts currently produced in this way are shown. The extent of possible improvement in classical forecasts if solar factors were included is discussed and the need for further co-operation in applying the Solar Weather Technique to modify Numerical Weather Prediction (NWP) is discussed.

THE SOLAR TECHNIQUE OF WEATHER FORECASTING: AN INDEPENDENT ASSESSMENT

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ABSTRACT

Most weather forecasts attempt to include a range of phenomena in their predictions. This makes comprehensive assessment difficult because forecasts can be correct in some respects, yet incorrect in others. Moreover it is often difficult to attach objective and numerical values to the degree of similarity between predicted and realised events. This report highlights these general problems and takes one example, that of gales prediction, to illustrate how assessment might be undertaken in an objective and statistical manner. At the same time the example chosen, that of predictions based on the Piers Corbyn "solar technique", allows some preliminary and, importantly, independent conclusions to be drawn concerning the usefulness of such forecasts and the integrity of the system by which they are prepared.

Solar technique-based monthly forecasts are prepared over six months in advance of the events that they attempt to predict. This assessment is based on forecasts for the period October 1995 to December 1996. It focuses on the prediction of gales and studies the success rates of those predictions against realised events. The assessment also examines forecasting "skill" by comparing observed success rates against those that might be achieved by chance, i.e. without any forecasting skill in the system. The probability of chance success is determined by reference to long-term average gale frequencies from which empirical probabilities can be deduced. The assessment is concerned not just with the efficiency of the forecasts but, inevitably, casts a light on the viability of a forecasting method that differs notably from those currently in use by the national meteorological services. The exercise is however empirical in confining attention to the forecasts themselves and their comparisons with the realised events.

The results suggest that the observed success rates are unlikely to have arisen by chance and indicate a degree of skill in the forecasting system. Gales are forecast with a notable degree of temporal precision and, usually, to within two of the events themselves. Even allowing for the probability of making such predictions based merely on long-term average frequencies, the success rate has a random probability well in excess of 1 in 100. The assessment is however confined to the gale element of the forecast which is the easiest to treat in this particular way. Other elements need also to be studied and it is not clear how far the gales element is diagnostic or characteristic of the forecasts as a whole. Nonetheless, the evidence thus far strongly suggests that such studies will repay attention.